Reverend P. Parker M.D.

from his humble serv—

Edwd. Cann

Canton 31st. March 1836

ELEMENTS

OF

GENERAL ANATOMY,

OR,

A DESCRIPTION OF EVERY KIND OF ORGANS COMPOSING THE HUMAN BODY.

BY

P. A. BECLARD,

PROFESSOR OF ANATOMY OF THE FACULTY OF MEDICINE OF PARIS.

Preceded by a Critical and Biographical Memoir of the Life and Writings of the Author,

BY OLIVIER, M. D.

TRANSLATED FROM THE FRENCH, WITH NOTES,

BY JOSEPH TOGNO, M. D.

MEMBER OF THE PHILADELPHIA MEDICAL SOCIETY.

Philadelphia.

CAREY AND LEA.

....

1830.

TO

THE MEMORY

OF

BICHAT, BECLARD,

AND

JOHN D. GODMAN.

THE TRANSLATOR.

THE TRANSLATOR'S PREFACE.

The task of the translator, although very confined, is not altogether unimportant to the advancement of the arts and sciences, and especially to the improvement of the medical science in this country, at this present time.

Forbidden to add to, or to subtract from the original, the translator's business is simply to interpret and translate his author's meaning faithfully, and to render it in clear and intelligible language.

It has been the fate of the translator of the present work, to give an English version of the last labours of the lamented Bichat; and now, again, the ten-fold more difficult, but pleasing task devolves on him, of presenting to the medical profession of this country, the last work of the eminent, erudite, and much lamented Béclard.

The object of the translator will be fulfilled, and he will be repaid for his trouble, if without deviating from his author, he has made the original, clear and comprehensible to his English reader. But should some stern critic, eager to find fault, censure the performance, which has cost the translator much labour, trouble and solicitude; and under circumstances that the reader is seldom solicitous to know, and seldomer inclined to make due allowance for; let him remember, that if this English version is not faultless, still much has been

done to render it worthy of the approbation of the profession. Indeed, I may well be contented, without claiming for this translation, the praise of perfection, while I daily witness similar attempts, coming from higher sources, not altogether exempt from errors.

For instance, since the greater part of this version has been printed, we have had in our hands the translation of the same work by Dr. Knox of Edinburg, well known to the medical profession as a writer and a lecturer. We opened this volume by chance in many places, and we have, not without great surprise, found some very gross errors. We will point out some of them, not to gratify malice or jealousy on our part, but merely to show that the faithful and correct performance of a translation, is not as easy a task as some critics would make us believe. Should we ourselves have fallen into errors, notwithstanding all our care and attention to produce a faultless translation, we wish thereby to show, that we are entitled to some indulgence from our reader.

Dr. Knox points out one single error in his erratum, and we turned to the page indicated; on reading the same paragraph, we found just above the error alluded to the following sentence, which we shall give with the original, and opposite to our own version. This induced us to look cursorily into the book, and to our great astonishment, we found such errors, in point of science, as made us rather tremble for the performance of the other parts of the work. We shall here quote some of the principal blunders committed by Dr. Knox, for the edification of our readers.

Dr. Knox's Translation.	*Text.*	*Dr. Togno's Translation.*
Page 210.—Paragraph 450. In the neighbourhood of the heart, the venous trunks which are destitute of valves alternately experience, during the contraction of the auricles, a reflux of blood *which makes them swell out during the relaxation of the auricles.*	Page 371. Au voisinage du cœur, les troncs veineux qui sont dépourvus de valvules eprouvent alternativement, pendant la contraction des oreillettes un reflux du sang qui les fait gonfler, *et un flux rapide qui les fait affaisser pendant le relâchement des oreillettes.*	Page 301. In the neighbourhood of the heart, the venous trunks, which are deprived of valves, experience alternately, during the contraction of the auricles, a reflux of blood which makes them swell out, *and during the relaxation of the auricles there occurs a rapid flux, which causes the veins to be depressed.*

Turning back to page 43, and in paragraph 66, we read the following phrase:

Page 43. Thus, in the nervous system, the spinal marrow, which is first developed, is more symmetrical than the brain; the ribs are *more symmerical than the vertebral shaft or the sternum.*	*Page* 74. Ainsi dans le systeme nerveux, la moelle qui se developpe la première, est plus symétrique que le cerveau; les côtes sont *moins symetrique qui le rachis, et plus que le sternum.*	*Page* 75, *paragraph* 67. Thus, in the nervous system, the medulla, which is first developed, is more symmetrical than the brain; the ribs are *less symmetrical than the spinal column, and more so than the sternum.*
Page 315. It was no doubt *from having in his view* muscles of this kind, that Gassendi compared the muscle to a MITTEN.	*Page* 557. Ce sont sans donte des muscles de ce genre qui avaient fait comparer Gassendi le muscle à un *moufle.*	*Page* 447. It was muscles of this description, without doubt, that induced Gassendi to compare the muscles generally to *a tackle of pullies.*

What connexion, what relation can there ever be between a muscle or muscles generally, and a pair of *mittens?* Unfortunately, the translator was not aware that *un moufle* had more meanings than one.

Dr. Knox's Translation.	*Text.*	*Dr. Togno's Translation.*
Page 249. "The *wings* of the trachea alone present a more or less extended ossification in the adult. In cases of phthisis, however, the cartilaginous *wings* of the *bronchi* have been found ossified."	*Page* 441. Les *cerceaux* de la trachée seul presentent dans l'adulte une ossification plus ou moins étendue. Cependant on a trouvé dans le cas de phthisie, les arceaux cartilagineux des bronches ossofiés.	*Page* 355. The *rings* of the trachea alone present a more or less extended ossification in the adult. In cases of phthisis, however, the cartilaginous *arches* of the bronchiæ have been found ossified.
* * * * * *	* * * * * *	* * * * * *
In the case of goitre, and even without this cause of pressure, the cartilaginous *wings* of the trachea, &c.	Dans les cas de goitre, et meme sans cette cause de compression on trouve quelquefois les *arceaux* cartilagineux de la trachée, &c.	In the case of goitre and even without this cause of pressure, the cartilaginous *rings* of the trachea, &c.

So that in this place we have *wings* both to the trachea and bronchiæ.

Page 305. At this age (childhood) also the muscular flesh is less red, and *more gelatinous and fibrinous* than in the adult age;	*Page* 538. A cet age aussi, la chair musculaire, moins rouge, est *plus gélatineuse et moins fibrineuse* que dans l'age adulte;	*Page* 433. At this age too, the muscular flesh is not only less red, *but is more gelatinous and less fibrinous* than in adult age;
Page 320. In every effort also, a great number of *efforts*, sometimes the whole apparatus of motion *together*, is in action.	*Page* 564. Dans tout effort aussi un nombre considerable de *muscles*, quelquefois l'appareil tout entier des mouvemens, est en action.	*Page* 453. In every effort, also, a great number of *muscles*, sometimes the whole apparatus of motion, is in action.

Page 309, *paragraph* 704. In the reservoirs, as well as in the heart, the fibres which are disposed in layers and bundles obliquely crossing each other, have the *form of circles* or *rings* fixed by their extremities to the sides of the aperture of the organ. The bundles of fibres in these organs *cross between each other* and unite, &c.	*Page* 54—5. Dans les reservoirs, ainsi qu'au cœur, les fibres, disposées en couches et en faisceau qui se croisent obliquement, ont *la forme d'anses fixées* par les extremités aux côtés de l'ouverture de l'organe. Les faisceaux dans les organes *se croisent entre eux*, s'unissent, &c.	*Page* 438. In the reservoirs, as well as in the heart, the fibres are disposed in layers and bundles which cross each other obliquely, they have *an arched form*, the extremities of which are fixed to the sides of the aperture of the organ. The bundles of fibres in these organs *cross each other*, and are united, &c.

Where is the anatomist that has ever described the bundles of muscular fibres of the bladder or of the heart to *have the form of circles* or *rings?* We should be, moreover, desirous to know, where are the *extremities* of a *circle* or *ring?* We shall make two more quotations from Dr. Knox's translation, and we shall stop; for it would require too much room should we be disposed to point out all the errors his translation contains.

Page 236. The thickness of the periosteum is variable, and proportionate *to that of the bones*.	*Page* 417. L'epaisseur du perioste ets variable, et proportionnée *à la vascularité des os*.	*Page* 337. The thickness of the periosteum is variable, and proportionate *to the vascularity of the bones*.
Page 249. Long continued maceration divides these cartilages into *fibres or filaments more or less short*.	*Page* 440. La maccration longtemps continuée divise ces cartilages en *fibrilles ou filamens mous et courts*.	*Page*, 354. Long continued maceration divides these cartilages into *soft and short fibres or filaments*.

We ought to say a few words in commendation of the original work of Béclard; but we believe its merits so well known that we shall dispense ourselves from dwelling on them. However, we know that there exists yet, among some of the younger members of the profession, a very false and erroneous idea of what GENERAL ANATOMY really means. In order to elucidate this subject, we shall extract the following excellent explanatory passage from a Lecture of Dr. Godman on *General Anatomy.*

"We have in the outset to regret that the use of a term should have led to misapprehension among some of the members of our profession, who from the title General Anatomy, have received an impression that it is nothing more than a general outline, or sketch of common or special anatomy, stripped of its minuteness.

"Such an idea of General Anatomy is totally erroneous, and has in some instances led to the most injurious neglect of precious knowledge. General anatomy is the science of organization, not of individual organs. It teaches the elementary textures composing all the parts of the body without reference to the specific structures they aid in forming. In this sense alone, it is *general*, but in the determination of the qualities and laws of the elementary textures, and of the manner in which these are linked together, this science is most minute, precise, and definite, bringing us into the most intimate acquaintance with the entire economy of the system, and breaking down the barriers which the habit of exclusively studying special organs, invariably raises around us.

"General Anatomy, then, is not descriptive or Special Anatomy in outline, but the anatomy of elementary textures, of

minute organization without reference to form or place. It is to Anatomical science what Chemistry is to the other branches of natural science. Whatever may be the texture examined, it is considered in all aspects, and throughout every modification, whether it be found in the substance of tendon, muscle, ligament or bone. All its qualities are sought, the distinctive characters established, and the laws of its susceptibilities and actions deduced from the amplest experiments and observations."

October, 1830.

CONTENTS.

PREFACE.

The work I publish is a compendium of a course of anatomy, which I have been delivering for these ten years past; and is solely intended for students of medicine. My object in publishing it, is to offer them, in a small volume, an abridgment of the numberless labours undertaken for more than twenty centuries, in the science of the organization of man.

I divide the anatomy of man into general anatomy, special anatomy of the organs, and anatomy of the regions. This volume contains only the General Anatomy, and may be considered either as a separate work, or as the first part of a general treatise.

In writing this part of Anatomy, I have made a liberal use of the work of our celebrated Bichat, as well as of those works which have since been published on the same subject. I have also consulted treatises *ex-professo*, for each system or kind of organs. I have been careful to quote in every chapter, the titles of the works which furnished me with the materials necessary to compose it, less with the view of making an easy and vain display of erudition, than to exempt others from the necessity of reading the works which I was myself obliged to peruse; and at the same time to point out, to those who are anxious to make farther researches and more profound studies, a sort of select anatomical library. I have also indicated the plates, which may be consulted with advantage for each kind of organ.

I have begun each chapter, with an abridged history of the principal discoveries made respecting the system of organs which compose it; to enable me, the better to compile some of these historical notices, I made free use of Lauth's History of Anatomy, of which as yet one volume only is published.

The introduction treats, in the first section, of organization in general, and in the second, of the human body. It was my intention, in the first section, to give merely to my reader a general idea of comparative anatomy and physiology. In so doing, it was not my object to exempt the student from studying the anatomy of animals; but on the contrary, to show them the utility of this kind of knowledge. In writing this part of the introduction, I have profited by the labours of Dumèril, Blainville, Geoffroy Saint Hilaire, Lamarck, and especially of those of Cuvier, whom I could have cited at every page. In the second part of the introduction, I have given general views of the human body; I have spoken of its humours generally, part of the science of organization too much neglected, since Haller and his school, who erroneously thought they had found the whole secret of life in the nervous system, and in the phenomena of irritability and sensibility.

Anatomy not being an object of mere speculation and sterile curiosity to the physician, but the basis of all knowledge relating to medicine, I thought that physiology and pathology, ought not to he entirely separated from it. Pathological anatomy, particularly, ought, in my estimation, to be connected with special anatomy, and in this view, the description of each tissue is terminated, by a brief survey of the varieties and alterations therein observed, and the whole work itself is concluded by a chapter on anomalous or accidental productions, common to all, or to several kinds of organs.

P. A. BECLARD.

Paris, August 30th, 1223.

MEMOIR

ON THE

LIFE AND WRITINGS

OF

BÉCLARD.

To write the life of a celebrated man, is at once to honour his memory, and confer a benefit on society; for, while we recall to mind the triumphs of him whose every step was crowned with success, we teach those who wish to imitate him, by what means glory is attained, and of what value, in this world, is a reputation justly acquired. It is with this double object in view, that we propose to lay before our readers, the laborious life of the learned man, whom the school of medicine of Paris will long regret, and of which he was one of the noblest ornaments.

Peter Augustine Béclard was born at Angers, October 12th, 1785. His parents had no other fortune than their good name, and in their family probity was hereditary. His father, although loaded with the cares of a numerous family, by a strict economy, was enabled to give to each of his children the elementary education, requisite to enable them to continue the limited business which supported them. Thus, when young Béclard had learned to read, write and cipher, he was made to understand that to *this*, the extent of his knowledge should be confined. But either because he had a foreboding of his future success, or that he was inspired by instinct, or by an irresistible inclination, Béclard, heedless of these remarks, eagerly read every book which fell into his hands.

The central schools, which had been established in the departments, and from the heart of which radiated the instruction destined to enlighten a regenerated nation, were then in all their activity. Béclard had himself inscribed as one of the pupils of that formed at Angers, and he was soon remarked for his proficiency and rapid improvement. Here, for the first time, he discovered the advantages of study; here he was imbued with the love of the sciences, and here he learned to worship them. Notwithstanding the illusions with which he already fed his ardent soul, his relations saw with sorrow such dispositions developed in him, and in order to keep him in the rank in which he was born, they from time to time, tried to make of him a clerk of a store, then of a lottery office, and at last secretary to the director of the stage-office. Béclard but ill fulfilled those employments for which he had great repugnance, and but little aptitude; and indeed, he was considered by his employers as unfit for the occupations of business. The disgust that he experienced in this situation, very unsuitable to his natural inclinations, from this moment tinged with melancholy the character of Béclard, which afterwards redounded to his advantage, by early preparing his mind for that kind of meditation which the profound cultivation of science always demands.

There is an epoch in the life of man, when as yet undecided on the profession he shall embrace, he studies, as it were, the part he is to perform on the theatre of the world, and prepares himself beforehand to fulfil it well. This period in the life of Béclard, was marked with such indolence, as reduced his family to despair; he is fit for nothing, said they, and neglectful of the future:—this was owing to their having misunderstood his secret intentions, and to the want of the aliment they required; but as soon as his father was enlightened by good advice, softened by the solicitations of his son, who only wished to become a surgeon in the army, and had permitted him to follow the medical courses established in the hospital of the same city, from that moment did the young student see opened before him a profession in which he ardently desired to

enter, from that moment also ceased that torpor which had so long held his faculties in chains.

He began the study of medicine in 1814. A circumstance soon presented itself, as if on purpose, to give to Béclard a knowledge of his powers: a competition occurred for the first time for the situation of resident physician in the hospital. One of the pupils, who since has been lost in the crowd, had then a reputation, we might say brilliant, for every age has its kind of celebrity, and was considered as a very formidable competitor; so much so as to fix the eyes of every one on him, for that situation. Notwithstanding this, Béclard so astonished his judges with the extent of his knowledge, and the precision of his language, that he was proclaimed the successful candidate. This was the first glimpse of that glory which was to shine on him, even to his tomb.

During his residence in the hospital of Angers, he consecrated almost all his time to the study of anatomy—a study for which he had a great predilection; he accustomed himself to observe every kind of malady, which were infinitely varied, and which presented themselves in an abode opened to all the miseries to which humanity is subject. He habituated himself to a skilful manipulation of the knife. He studied with expert masters, among whom *Mirault* was a distinguished practitioner, and whose name is enrolled in the pages of our art. He learned, I say, to interpret with wisdom, and without prejudice, the facts which abound in our science, and from which we are often exposed to draw conclusions favourable to our favourite opinions; finally, he received from this school, more useful than celebrated, the germ of a correct knowledge, and of that eclectic and rigorously exact mind which afterwards rendered him so valuable a man. The example of Béclard, and his success, prove, better than a long argument, the utility of elementary or secondary schools of medicine, where the number of pupils being small, they have a better opportunity to observe for themselves, and consequently, are enabled early to obtain that experience which in the larger schools, the eager crowd of students never acquire but with the greatest trouble. Thus we see him leaving the retired scenes of his first studies,

already rich in scientific lore, if not very extensive, at least very positive.

During the first years of his medical studies, he devoted himself to the study of the Latin language and philosophy, which the clergyman attached to the hospital taught him, and who delighted to instruct a young man already so rich in knowledge. He cultivated at the same time Botany; he obtained several premiums on subjects of natural history, and by his zeal, ardour, and success, from this time, gave hopes of a brilliant career. Béclard, during his residence in the hospital of Angers, left to his successors a noble example of emulation which will be long remembered.

At this time Bichat had reached the middle course of his career, and filled the learned world with his glory and his name. In the many conversations young Béclard had with his relations, he often remarked how happy he should be if he were one day able to cope with the *Father* of *General Anatomy* and become his equal. Bichat was his idol; he was anxious to render homage to his genius and be considered one of his followers. Unfortunately for Béclard, Bichat died before he was able to attend his lectures, for it was not until 1808, that he went to Paris; but he had carefully transcribed notes taken at the last course of this celebrated anatomist.*

In 1808, Béclard was distinguished in the first rank of the pupils of the Practical School or clinical courses, and of the hospital of Paris. In 1809, premiums were conferred on him by the medical school, on subjects of anatomy, physiology, medical natural history, chemistry, and physicks. He was soon after appointed resident physician (*éleve interne*,) to various hospitals. He again, 1810, received premiums on anatomy, physiology, medicine and surgery; and Mr. Roux selected him for the honourable office of preparing and repeating lectures at the hospital of La Charité.

Hitherto, Béclard was only known to his rivals in fame, and to his friends; and all his merit only consisted in a vast

* This passage alludes particularly to the work of Bichat on Pathological Anatomy, which was published from an authographic MS. of Béclard, and which are the only authentic notes we possess of Bichat's last course.

TRANS.

memory and an easy elocution. His genius had not yet assumed a determinate character; as yet, no original production had unveiled his resources; but at last an important occasion of distinguishing himself occurred. M. Dupuytren being appointed to the chair of operative surgery, the place of adjunct professor of anatomy in the faculty of Paris became vacant. Béclard, being appointed assistant, in 1811, he presented himself as a candidate, and to him was awarded the prize by the judges. He had already acquired the esteem of a great many students who had followed his private courses. He had scarcely any reputation as an anatomist; but as soon as he saw that he was surrounded with so many means of instruction, he hastened to improve himself by taking advantage of the opportunity presented to him. Besides, he had already indicated in the thesis that he presented for the above mentioned situation, in the most luminous manner, what ought to be the conduct of the superintending adjunct towards the pupils in the pursuit of anatomical knowledge. It was therefore expected, that faithful to the principles that he himself had laid down, he would not fail to put them in practice; and it is well known that he did not belie the hopes, that his zeal and precocious talents had led the profession to expect.

Among the interesting facts collected by him, in the dissecting rooms of the medical school, and which he presented to the society of the professors, among whom he was very soon received, we will only mention the principal ones. Such was the observation of a fœtus born with a frontal and very voluminous hernia of the brain, being the consequence of hydrocephalus. This preparation was rendered particularly curious by the extraordinary existence of two bones situated between the frontal bones and not far from their articulation with the ossa nasi.

Soon after, he gave the description of a fœtus, of which the umbilical cord very much dilated at its base, contained a part of the abdominal organs, and the heart of which adhered to the palate. He published, conjointly with M. Bonnie, a case of labour per ano, of a child the conception of which was extra-uterine. In a memoir on necrosis, he maintained and de-

veloped the opinion of some authors who think there is in reality no regeneration of bone. He also made public his reflections on the formation of the callus; he demonstrated together with Bonn and Bichat that the ossification of the periosteum was only momentary, and served as a sheath to the two fractured extremities during the time they are cemented with phosphate of lime. It had been supposed for a long time, that the curvature of the aorta produced the lateral curvature of the dorsal region of the vertebral column. Bichat had already shaken the general belief of this supposition, by supposing that it might be caused by the often repeated contractions of the muscles of the right arm; this however was only a supposition, but Béclard demonstrated it to be a positive fact by numerous researches upon this subject. We must not omit to mention, the physiological experiments he performed in order to prove that the fœtus has respiratory movements while in the uterus, by which it introduces the waters of the amnion into the bronchiæ. He was, however, unable to demonstrate that this liquid has a chemical action on the blood which enters the lungs. It was also at this time that he made, with the assistance of Le Gallois, a series of curious experiments calculated to determine the action of the œsophagus in vomiting.

In 1813, Béclard defended before the faculty of Paris his thesis for the degree of Doctor of Medicine; it contains several propositions, which treat: 1st, of the distinction to be established between the lamellated and adipose tissues; 2d, of the projection and depression of bones, which he conceives to be induced by the primitive formation of the cellular web of the bone, and not to the traction of the tendinous attachment of the muscles. Some of his labours already cited, are again presented in this Thesis, which concludes with a learned interpretation and with practical observations on the method of performing the lateral operation proposed by Celsus. His talents as a surgeon had been already justly appreciated; and in 1814, at the time of the first invasion of France by the allies, he was appointed by government to give his professional aid to the wounded soldiers brought to the *ambulance* established at the Hospital Saint-Louis. His Memoir on Acephalus appeared in

1815. He also communicated at this time, several facts of pathological anatomy, that he had observed in the dissecting rooms of the Practical School.

A competition then arose for the place of second surgeon of the Hôtel-Dieu, and Béclard, for the first time, was unsuccessful in this kind of contention: Mr. Marjolin was his opponent. As the two candidates, however, had contended for the victory, with equal merit and talents, Béclard was appointed surgeon to the Hospital of La Pitié. He had already acquired a considerable skill in the art of *Paré* and of T. L. Petit, under a master who loved him tenderly, and with whom he was afterwards united by the most affectionate ties of friendship. Dubois had taught him operative surgery, at the school of *Perfectionnement*, and it is not astonishing, that Béclard should have soon developed a talent truly surgical, to which, however, his natural dexterity, and his daily habit of dissection, had already predisposed him.

In 1816, he became a member of the Philomatic Society, and he gave, for the first time, a course on General Anatomy. In 1817, appeared his researches on the wounds of arteries. The experiments of Jones, in England, were scarcely known, when our anatomist thought it proper to give them a trial, and the result of his labours confirmed the conclusions drawn by the English experimenter. This memoir is to be found among those of the *Société d'Emulation*, of which he was a member. In 1818, he published with Mr. J. Cloquet, a translation of Lawrence's treatise on hernia.

It was also during the same year, that the faculty of medicine, of Paris, received him as one of its members. This memorable event in the life of Béclard, in adding new lustre to his reputation, inspired him with the noble ambition of rendering himself equal in talent to the celebrated professors of that faculty, old in glory and experience. Thus, did we see him redouble his efforts, in order to fulfil with dignity and talent, the chair which had been entrusted to him. The eagerness with which the students attended his learned courses on Anatomy, was the best pledge of the propriety of the selection the faculty had made, of this remarkable man.

He aided in the formation of a scientific selection then known under the name of the *Nouveau Journal de Médecine*, of which, *Les archives, générales de Médecine*, are now a continuation. In 1819, he published four memoirs on *Osteosis*,* of which disease, he described the progress with the greatest precision and perspicuity. He cooperated in the publication of the Dictionary of technical terms of Medicine, Surgery, Pharmacy, &c. and was one of the principal colaborators of the *Nouveau Dictionnaire de Médecine.*

In 1820, he was appointed president of the board of Juries of the department, and member of the council of health of the department of the Seine. When a royal ordinance had created the Academy of Medicine, (December 20th, 1820,) public opinion pointed out Béclard, and he was unanimously elected to fulfil the functions of secretary for life of that learned body, functions that he exercised, until ministerial favour disposed of his office otherwise.

In 1821, he published a volume of additions to the general Anatomy of Bichat, and the following year gave to Mr. Descot, the result of his experience and researches on the local affections of the nerves, which the latter recorded in his thesis. In 1823, he published his *Elements of General Anatomy, whence students may long draw the most important lessons which have hitherto been given on the organization of the human body.*—At this time Béclard was included in the general disgrace of the old faculty of medicine, and when the reorganization of the new school was about to take place, he came very near being excluded, but his great reputation and his talents got the better of every kind of intrigue and opposition which arose against him, and the chair on which he had shed a new lustre, was restored to him.

This rapid recapitulation of the labours most remarkable in the life of Béclard, brings us to a gloomy epoch; but before entering on this painful part of the task we have prescribed to ourselves, let us return to the particulars of the life of a master so dear to us and one who honoured us, with so benevolent

* Béclard has given this name to the branch of anatomy which treats of the developement of bone.

a friendship. Let us therefore consider Béclard, as an anatomist, as a surgeon, as a professor, and as a private man.

Anatomy had been the first object of the studies of Béclard. His retentive memory enabled him to recollect most faithfully the minutest descriptions; his skill enabled him to perform the most difficult dissections; and his great judgment placed him far above a great number of pupils, whose whole ability consists in discovering a muscle, or in following up the minute ramifications of an artery. Endowed with the threefold gift of dissecting well, of seeing well, and of remembering exactly the relations and disposition of parts, he had in himself, all the requisite qualifications to make a good anatomist. When he arrived in Paris, anatomy and physiology, already greatly improved by the researches and labours of Haller, Bordeu, and Bichat, beautifully adorned with all the brilliancy of their genius, powerfully enticed a great many students, both by the attraction of the new discoveries, and with the hope of the many useful applications they would be able to make of them, in the practice of medicine and surgery; consequently, this science was cultivated with an indefatigable ardor, which was kept up and increased by the example and encouragement of such men as Portal, Chaussier, and Duméril. At this time Pinel had already established important distinctions in the curative art founded on Anatomy; and the school, of which he was the leader, followed with enthusiasm the impulse given by this philosophical physician. It was at this time also, that the indispensable and inseparable knowledge of the organization, and that of maladies were intimately united; and in order to render it still more necessary, while Messrs. Richerand and Dupuytren were instructing the medical profession with the healthy action of our organs, Messrs. Bayle and Laennec were pointing out the different modes of alterations they were susceptible of experiencing.

It was very natural that Béclard should eagerly embrace the prevailing opinions of his age, the more so because he was capable of foreseeing all the good that the science might derive from it. He never confined himself therefore to the dry and sterile study of descriptive anatomy; he always con-

sidered it in its relations with Medicine and Surgery. He consecrated the whole of his time to the study of the relations of the parts with each other, to the varieties of forms and directions that circumstances may cause them to experience; and not being able to find, in the immense number of facts which he daily observed, means sufficiently vast to multiply his learning, he was seen thirsting for more knowledge, to extend beyond conception the limits of his erudition. Full of admiration for the German school of medicine, to which we owe so many valuable discoveries in the science of organization, he early familiarized himself with the labours of Meckel, Oken, Tiedemann, &c.—He also profited by the discoveries of the celebrated men of Great Britain and Italy; and it was not until he was possessor of an immense mass of facts gathered, so to say, from every quarter of the civilized world, that he minutely and carefully scrutinized, aided by his vast experience, every fact, every opinion, and every theory.

Some men, envious of his glory, accused him of being a mere compiler, a man of erudition, but denied that he possessed even the smallest particle of genius. Let us not forget, therefore, that in following this course, and in fulfilling so difficult a task, Béclard needed to possess a correct and rapid intellect, an uncommon eclectic mind, and a very superior power of reasoning. The parallel that some persons have tried to establish, between Bichat and Béclard, can not really exist. If these two men have between them some resemblance as to their early and rapidly acquired glory, and unexpected and premature end, they essentially differ as to the manner in which they cultivated that science they have equally improved. Rich with his own native genius, carried along by the desire of constructing the medical edifice on a new plan, Bichat hastened to arrange the materials for which he was almost entirely indebted to his own researches. Béclard, on the contrary, formed in his mind the vast project of collecting all the scattered facts belonging to the science, in order to create with them a code of doctrines authorized by the most celebrated names, and supported by the result of

the meditations of the most learned men. Béclard preferred the merit of making truth shine, it mattered not from what quarter it proceeded, to the dazzling glory of being an inventor. He was unaffectedly the greatest admirer of Bichat, and if he has often been obliged to controvert his opinions, it was because the interest and the advancement of the science demanded it.

The same distinction which has been made between Bossuet and Massillon, might be established between Bichat and Béclard. The Bishop of Meaux was one day preaching to an illustrious auditory; Massillon, who was listening to him, said, "This is very well, I admire him; but, if I were in his place, I should preach otherwise." Such was the conduct of Béclard with respect to Bichat. Cooler and less enthusiastic, he came after him, as it were, to correct the errors which had passed unnoticed by the inventive genius of that great man. Let us therefore cease to establish between them a comparison which does not permit us to judge of either, according to his respective merit. They are only to be considered singly, and then their individual merit will cause us to admire them the more.

It is in consequence of this plan of reform and improvement, that Béclard first published a new edition of Bichat's General Anatomy, with a volume of additions, and in the same spirit of improvement, he afterwards brought to light his Elements of General Anatomy, a work remarkable for its clearness, the great number of truths it contains, the extensive plan on which it was written, and the immense erudition therein displayed. This work has been compared to the Manual of General, Descriptive and Pathological Anatomy of Meckel. It is very true that the French anatomist has been sometimes benefited by this great collection of facts more or less interesting; but how much the imitator has surpassed his original; with what art he has avoided those German ideas, those hypothetical explanations, and those often far fetched analogies with which the General Anatomy of Meckel is interspersed. On the other hand, the work of Béclard is compared to that of Bichat, the enchanting style of which is con-

tinually praised; but we must not forget that Bichat wrote at a time when it was necessary to entice the reader by the charm of diction, while Béclard wrote for sober men, whom science alone can seduce, without the artifice of meretricious ornaments. Béclard carries in himself the distinctive marks of his age. Bichat has written, as is said, the romance of the science, but Béclard has striven to fix its laws, and to draw up its code. Thus, the General Anatomy of Béclard possesses its peculiar merit, and may be considered as one of the most glorious titles of the author to immortality. To conclude, this learned man has especially studied and improved anatomy, in its relations with medicine and surgery, and by strengthening the foundation of this science with an unlimited erudition, has really founded a school, the principles of which will be long followed.

To the valuable qualities that we have just enumerated, Béclard added those of a skilful operator. He was endowed with a steady presence of mind, with a firmness which never approached harshness, and with a dexterity which was the result of his many dissections. Unforeseen circumstances sometimes obliges the operator to deviate from the general rules of the art. Béclard, on these occasions, knew how to modify a method, or invent a new one to suit the case. His composure never abandoning him, his memory recalled, or his genius often suggested to him, during an operation, every thing requisite to insure its success. He has invented or improved the methods of several operations: such are his method for curing the fistula of the duct of steno; several methods for the partial amputation of the foot, the amputation of the articulation of the metatarsus, the amputation of the articulation of the shoulder and hip joint. He has also modified the manner of cutting through the soft parts in amputating limbs, and the method of sawing the tibia in the amputation of the leg. He was the first who removed the parotid gland;* finally

* It is strange we should so often read of European surgeons extracting this gland, while in this country some of the greatest authority in surgery deny the possibility of the operation. On the one hand, we can not suppose that these surgeons wish to impose on us, and on the other, to say

he modified to great advantage the method of Celsus in the lateral operation.

His vast erudition was equally extensive in surgery. In his lectures, delivered at the Hospital of La Pitié, he gave unquestionable proofs of an extensive and solid knowledge. Even those who confined themselves to his course of lectures on surgery, and who disdained to attend his operations, exhibited on a very modest theatre, could not, at least, deny him the merit of being extremely well versed in Surgical literature. He was always the general admiration of his audience, in seeing with what extraordinary talent he developed and commented on the theories of those men who have written on this branch of the healing art. It is useless to endeavour to avenge here Béclard for the character with which he was reproached, of being a surgeon only in theory. Let us not mingle with the pleasure we experience in recording the merit and talents of this excellent man, the bitter remembrance of the numerous persecutions and ridiculous cabals, of which he was the object. The reputation of Béclard, as a professor, was spreading more and more every day. He possessed the very rare faculty of presenting methodically, with precision and simplicity, all that his extraordinary memory had retained. He was particularly happy in the selection of his words and in the construction of his phrases. He preferred precision and vivacity of expression to elegance. His language was parsimonious of metaphors; but he developed his ideas by a gradation of words admirably chosen, so that the last ex-

that such great anatomists as Béclard, and a great many other European surgeons, such as Speranza, Lisfranc and others who published, having removed the parotid, have been mistaken, and that they have only extracted an enlarged lymphatic gland, is more than we are disposed to assert. That this may have been sometimes the case, I entertain no doubt, for three years ago, Dr. Gibson performed an operation which, as he correctly observed, might have been palmed on a class of students, as being an operation for the removal of the parotid, whilst it was only an enlarged lymphatic gland. But at the same time, if any reliance is to be placed on the word of Béclard, I think we can not deny him the glory of having performed this difficult operation. TRANS.

pression being the most impressive and the most energetic, left in the mind of his audience the image of the object, or the idea deeply impressed. He slowly prepared, and for a long time matured his lessons; being perfectly master of the subject on which he was about to lecture, he never was in the least embarrassed before his pupils. He always united the result of his own meditations, to the knowledge he had acquired: he interested and captivated his hearers without having recourse to a vain show of language, by which the deceived multitude is sometimes seduced.

In his last course he gave an anatomical and physiological history of the nervous system; a delicate and truly difficult subject. Nevertheless, his descriptions were so very clear and there was in them so much order, that it was impossible not to understand his lectures. He has presented with the greatest perspicuity the endless opinions advanced on this subject from Praxagoras down to this present time. His lectures were now more attractive and more instructive than ever, and as if presageful of his approaching end, he always lectured more than the time allotted to him, and could not withdraw from that chair, which soon a funeral mantle was to shade.

If Béclard had his equals in some branches of the healing art, as a lecturer he was surpassed by none; but on the contrary he eclipsed most of his cotemporaries. He reminded us of the knowledge and eloquence of Hallé, and was at least equal to Cuvier, whom, however, he delighted to imitate, and to the height of whose reputation he, by his vast knowledge, was every day attaining. He failed only in one respect, and that was, his not being able to draw, and in so doing to render even more striking his descriptions; had Béclard possessed this talent, he would have been the most astonishing professor, that the medical sciences had ever had as their interpreter, till the present time.

It is not common to meet with the virtues which adorn a private character united to great talents; because ambition, the ordinary source of our misdeeds, often accompanies genius, and by wishing to gratify that, we are exposed to deviate

from the rules of social morality. This can not be said of Béclard. If he desired to occupy a distinguished rank among his fellow men, it was never at the expense of those who followed the same career as himself, that he attained it. His success in the numerous competitions he had for various offices, had distinguished him from the multitude, and he maintained himself in the elevated rank he occupied, by his personal merit, and his indefatigable labours. He has been accused of being ambitious; but his noble emulation was ill interpreted; if he desired to become rich, it was the better to relieve a numerous family, of which he was the glorious support. Could a man be ambitious, who delivered public lectures for more than two thirds of every day, thus neglecting to seek a practice that his great reputation could not have failed to procure him? Simple and modest in his taste and habits, he delighted to live quietly in the bosom of a family that several kinds of talents contributed to render illustrious.

Béclard was naturally melancholy and gloomy. His health, exhausted by long continued studies, demanded the greatest care. Always intensely occupied with abstract ideas, his manner at first was cold, and his conversation very laconic; but if by any means he was enticed away from his favourite meditations, then his mind was perceived to be ornamented with the lore of philosophy and history, and to possess all those charms which a man remarkable for the brilliancy and variety of knowledge can infuse into his conversation. His hilarity and cheerfulness appeared only at intervals and quickly vanished; an irresistible charm seemed soon to recall him to the habitual sphere of his thoughts. For some time past, he had given a great deal of his leisure to the perusal of works on philosophy and political economy; he had also bestowed much time on the study of languages, so that he was able to make in society a display of another kind of merit very different from that with which he obtained the applause of the medical profession.

Béclard was benevolent without ostentation. A great many students received from him benefits of every kind, and he often left them ignorant whence they proceeded. He more

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than once abandoned to some of his pupils his discoveries and medical opinions which soon created and supported their reputation, and who afterwards became an honour to their illustrious master. He zealously aided them in their studies, and encouraged their labours; he was prodigal of the wealth of his immense erudition, and assisted them with the greatest zeal in the cultivation of a science of which he ardently desired to see the limits extended.

It was in the midst of so many useful labours, and when he began to enjoy a reputation, which, though already great, was yet only dawning, that the celebrated professor of whom we have just sketched the life, was seized with a mortal disease.

On the 6th of March, 1825, an erysipelitous inflammation appeared on his face, which soon spread over the integuments of the cranium. From its first appearance a cerebral exaltation had manifested itself, and inspired the greatest fears for the life of the patient. Notwithstanding all the most attentive cares, the malady advanced with a frightful rapidity, and on the 16th of March, Béclard was no more.

During the prolonged delirium which terminated his life, his intellect had acquired an astonishing activity. More than once we observed him, while in this state, supposing himself in the presence of a large audience, and developing with a surprising energy, ideas which, although incoherent in themselves, nevertheless disclosed the powerful and elevated mind which gave them birth. They were, in a manner, the last efforts of his expiring genius. Finally, after a long and painful agony, he breathed his last in the arms of numerous friends, that were bound down with grief at his bed side. As soon as the news of his death reached the School of Medicine, the pupils who for several days previous had been constantly moving about his house, in order to learn the state of his health, these same pupils who not long since saluted with general applause their learned and modest professor, were now deeply afflicted, and bitterly lamented the loss of so valuable a teacher.

On the 17th of March, 1825, the day of his burial, two thousand students met at his house, and would not permit other hands than theirs, to carry to their last abode his pre-

cious remains. They themselves transported the body of Béclard to the church of *Saint Sulpice*, which in an instant was filled with *Savans*, professors, and students. It was with the same eagerness, that the students, desirous of paying a last mark of respect, admiration, and gratitude to their teacher, carried his remains to the burial ground of Perè-La-Chaise. Those who could not have the honour of bearing this precious relicks, followed it in a mournful silence. In this manner it may be said, that he had a more imposing attendance than the ordinary and paid for pompous display, which surrounds the funeral car of the rich and powerful.

The Royal Academy and the School of Medicine, appointed a man of known eloquence to celebrate the last honours due to the manes of Béclard. The pupils, on their side, desirous of giving to their master an everlasting pledge of their sorrow, opened immediately a subscription to erect a funeral monument to his memory. The School of Medicine of Paris, and the friends of Béclard, imitated the generous impulse of his younger admirers, and we soon beheld rising over his grave, a monument which will long recall to our minds the talents of Béclard, the universal regret of which he was the object, and the noble admiration of studious youths for the teacher to whose lessons they had listened with so much eagerness; and, who, victim as he was of his ardour for acquirements and zeal for public instruction, died when only 39 years old, and when he was about to reach the zenith of his glory.*

Paris, December 15th, 1826.

* While the School of Medicine of Paris was deploring the loss of Béclard, the city of Angers, not less afflicted with so fatal an event, wished also to honour the memory of a man who had done so much for the glory of his country, appointed M. David his countryman and friend, and equally celebrated in his art, to execute in marble the bust of the rival of Bichat.

INTRODUCTION.

§ 1. The object of anatomy is the study of organized bodies; it is the science of organization, and all organized beings are the subject of it. Man, the most complicated of all beings, is the principal subject of this science. The special aim of Anatomy, is the knowledge of the human body, of the different parts of which it is composed, and of the relations of these parts with respect to each other.

Comparative anatomy, which might have been very well called general anatomy, embraces all organized bodies; it has for its object to seek, by comparison, which parts they possess in common, and in what they differ from each other. Phytotomy is the general anatomy of vegetables, that of animals is called Zootomy. Anatomy is still called general, when it treats of a class, a genus, or of any group whatsoever of organized beings; as for instance, that of domestic animals, or veterinary anatomy. Special anatomy has for its object one single species of organized bodies; such is the anatomy of the Elephant, Horse, Man, &c.

In the anatomy of man, the expression *general anatomy* has another acceptation, which will be mentioned hereafter; but we must first give a correct idea of organization in general, and of the bodies which are endowed with it.

SECTION I.

OF ORGANIZED BODIES.

§ 2. The endless science, called Natural Philosophy, or physics, the science of nature, treats of bodies which are ex-

tended and moveable beings. They may be considered under two different points of view: in a state of quiescence and in that of motion or action. While we consider objects with reference to the first of these, we particularly observe their form, either external or internal; it is to this kind of study, sometimes termed Morphology, that anatomy belongs. The second, to which is generally affixed the name of physics, treats of their appreciable changes, i. e. of their phenomena or movements, either as masses, or as molicules, and for this reason is divided into two principal branches, Mechanics and Chemistry.

§ 3. Bodies which have common or general properties, vary, however, in many respects. Organization and life constitute a very distinctive character which divides them into two very different series; that of inorganic bodies, and that of such as are organized and living.

§ 4. It would be useless to dwell longer on inorganic bodies, which not having a complicated structure, and their particles being entirely independent of each other, can not consequently form the subjects of anatomical consideration. It is sufficient to say, that the movements or phenomena of masses executed by these bodies, the object of mechanics, are reproduced with a regularity and constancy which permit us not only to observe them, to produce and repeat them in experiments, to determine the laws by which they are produced, but to submit them to a mathematical analysis: that the molicular phenomena of these same bodies, the object of chemistry, may be observed, and may be produced or determined at pleasure by experiments; that certain laws, according to which they are produced, may also be deduced from actual observation and experiments; but that these phenomena are yet beyond the reach of calculation, an instrumental science so well adapted to hasten the progress of those to which it can be applied. The science of organization and of life, is nearly confined to the laws of observation.

§ 5. Anatomy treats only of organized and living beings. Besides the characters which they possess in common with inorganized bodies, they have others which are peculiar to

themselves, and which modify the former: they have organization and life. They have each of them a special and unalterable form, ordinarily rounded, which is apparently owing to the fluids they contain. Their internal form or structure, presents, in fact, a mixture of heterogeneous parts, some solid, and some fluid. The solid parts are called *organs*, which means instruments, because of the action they exercise. Their particles are intertwined, interwoven tissues, their arrangement also being called texture; they are areolar, spongy, or form special cavities, which contain the fluids. These parts may be generally extended or elongated, and are endowed with elasticity. When these parts, or organs are multiplied, as is commonly the case, each one has its determinate form, its peculiar texture, and its proper situation. The liquids, or humours, are contained in the solids, and penetrate through every part. All the parts, be they solid, or fluid, are held in a mutual and necessary state of dependence upon each other; and it is from their union, that organized bodies originate. The solids and fluids have an analogous composition; they contain much water, and some particular combinations, or proximate materials, and may be almost entirely resolved into gas. The substances composing them, have nothing peculiar; they are also to be found in the inorganic bodies whence they have been drawn, and the line of demarcation, which distinguishes organic from inorganic solids, consists less in their nature than disposition. It is erroneously asserted, that the matter of organic solids differs materially from inert matter; for oxigen, hydrogen, carbon, and in a great many azote, and some earthy substances, are the ultimate elements of them all.

It is to this peculiar form, to this structure, common to every living body, this areolar or net-work-like tissue, containing liquids in greater or less abundance, and of the same nature as itself, that the appellation of organization has been given.

§ 6. We understand by life, the phenomena peculiar to organized bodies taken as a whole. Life consists essentially in this fact, that all organized bodies during a determined period,

are centres penetrated by foreign substances which they appropriate to themselves, and from which issue others that become foreign to them. In this movement of momentary formation, the matter of the body changes continually, but its form still remains. It is in the liquid state that foreign substances penetrate organized bodies ; it is also in the state of fluidity that the superfluous molecules are cast off. The liquids and solids are incessantly in motion during organization; the liquids traversing the cavities of the solids, while the latter, by their dilatation and contraction, produce the greater part of the movement of the former. They continually change the constituent parts of one into the other, part of the moving fluids becoming for a time solids, while some solid parts are converted again into liquids, which exchange perfectly agrees with the analogy of their composition. Organized bodies experience changes during the whole course of their existence ; and from the moment of their origin they increase their dimensions and density. This latter kind of mutation continues until the structure of the body being insensibly altered, the vital movement languishes and at last stops, which constitutes death; after this, the elements which composed the organized body separate, and form new combinations. Each organized body having not only its external form, but its own peculiar structure, each of these parts contributes by its action to the general result. The appellation of function is given to the action of each organ, or to the combined actions of several having the same end.

Nutrition, a function comprising absorption, assimilation and excretion, of which we have just spoken, is not the only phenomenon common to organized bodies; generation is another equally as general, and without which species could not exist, death being the necessary consequence of life. Every organized and living body originates from one resembling itself, and each produces its like. In order to accomplish this object, a part of an organized body which had already attained its full size, having received from it the materials for its own growth, separates from it and produces a being in every respect similar to its parent, and presenting the same phenomena. This part

is called germ as long as it forms a portion of the body of the parent. This latter general phenomenon is only a consequence of the former. As long as the germ makes a part of the body of the parent, it is nourished and grows as one of its organs; its separation constitutes a kind of excretion.

Most of the organized bodies also reproduce parts of which they may be deprived; they likewise repair to a certain extent the lesions that they experience.

The mass of individuals born of the same parents, and of those which resemble them as much as they themselves are like to each other, constitute a species. External circumstances, such as the atmosphere, food &c., as they are more or less favourable, influence organization and its phenomena: hence results a greater or smaller degree of perfection in the development, and differences of similitude, generally, somewhat limited between the individuals of the same species; and this constitutes the varieties. From this also results various individual alterations in organized and living bodies: these alterations of organization and of its phenomena constitute disease.

This series of phenomena is common to all organized bodies, and may be summed up in the following manner: The origin is derived from a being similar to itself, the end terminates by death, the maintenance of the individual is obtained from nutrition, the continuance of the species by generation; in a word, it is the reception of an action of momentary formation, exercised in a body which has received its principle from a parent, and transmits the same to its offspring, that is called life.

The two characteristic marks, which essentially distinguish organized and living bodies, and which are common to all and peculiar to them alone, are organization and life.

§ 7. The form and the action of organized and living bodies, organization and life, are so closely connected, that whenever we observe the one we may be certain of the existence of the other; indeed the one always pre-supposes the other. We never observe life but in organized bodies, and we never observe organization but in living bodies. In fact, in order that

life might exist, it was necessary that there should be solids to preserve the form and fluids to keep up motion, in a word, an organization; and in order that the latter should be enabled to exist in the midst of causes, all tending to its destruction, it was requisite that there should be a continual motion and renewal of its parts. Organized bodies are born alive from bodies alike to themselves, i. e. they are viviparous; in all, and during the whole term of their existence, the vital phenomena are in exact proportion to the state of organization; and when this latter is altered, either from the mere fact of possessing life, or from accidental circumstances, life languishes and ceases, and organization is destroyed by the chemical action of its own elements. Among all those who observe the phenomena of nature, no one has ever been able to detect matter in the very act of organizing itself, or life establishing itself, either spontaneously or by external causes, elsewhere than in bodies, already living and organized. Life, in fact, does not solely consist in a reunion of molecules which were before separated, as occurs in the case of chemical attraction, nor simply in an expulsion of the elements previously combined, as in that which is produced by the repulsive action of caloric; but in a movement of temporary formation, in which some elements remain united, which would separate should life cease, and in which the elementary parts are separated, without the action of caloric; now, this vital action exists only in organized bodies. This close and reciprocal connexion of organization and life, is the reason why they have been by turns considered as being the cause or the effect of each other. This, doubtless, is wrong; organization and life are a complex idea, which should no more be divided, (unless abstractedly), than these two things themselves, which are inseparable. Life is organization in action, or, according to the happy expression of Stahl, is the organism. The object of this work, however, being the examination of organization in a state of rest, life will be merely alluded to.*

§ 8. Organized bodies having a heterogeneous structure,

* See Richerand's Elements of Physiology.

their history is composed of that of their various parts; and and it is properly this study which is the object of anatomy. The physical state of these bodies does not only embrace mechanical or chemical phenomena, but also those which belong to them in proper, and which are not possessed by inorganic bodies, viz: nutrition and generation, i. e. the organic or vital actions. These particular physical laws assume the name of physiology.

Anatomy* then may be defined the knowledge of organized bodies, or the science of organization. According to its etymology, this word has another signification: it simply means *dissection;* but it has been consecrated by custom, and it is preferred to the words morphology, organology, (a discourse on form, organs), that have been proposed as substitutes. Anatomy, in fact, is a science of mere observation, and dissection is the principal means by which we expose the parts of organized bodies in order to be able to observe them.

Physiology† is the knowledge of the phenomena of organized bodies, or the science of life; it is also sometimes called Zoonomy, (laws of life,) and biology, (discourse on life). Physiology, like anatomy, is a science of observation; but it treats of the phenomena of organized and living bodies.

Anatomy and physiology are closely connected; having been taught by observation, that organization and the phenomena of life are always in a reciprocal relation, we may infer the condition of the one by the state of the other.

§ 9. Organized and living bodies, the subjects of anatomy and physiology, are divided into inanimate beings, or vegetables, and animals or animated beings; this division is derived from the *well marked* difference existing between animals and vegetables of a complicated organization, but is very little so, among those the organization of which is the simplest of all.

§ 10. The most complicated vegetables are generally formed of two distinct parts, separated by a median horizontal line, one descending, and contained in the earth, is the root; while

* From Ανατεμνω, I dissect.

† From φυσις, nature, and λογος, discourse.

the other ascending and surrounded by the atmosphere, is the stem, body, or tree which bears the leaves and flowers. Their structure consists, simply, in an areolar tissue, vessels and spiral tubes, which are called tracheæ. They possess no other organs than those of nutrition and generation. Their most important and vital parts are all situated externally. Their chemical composition is rather simple; nitrogen is seldom met with in them, and if found at all, it exists only in some particular part. Their vital action is confined to their growth and reproduction. Their nutrition, the materials of which are drawn from the earth and atmosphere, from water and air, consists in an absorption induced by the roots, by a movement of translation that the liquids experience in the vessels of the stem, and in a kind of respiration which occurs principally in the leaves: in these various actions vegetables retain hydrogen and carbon, little or no nitrogen, and exhale the superfluous oxygen. Their reproduction is induced in divers manners. There is, moreover, in the organization of vegetables, a very great diversity, which can not be properly treated of in this work.

OF ANIMALS.

§ 11. Animals, at the head of which is man, who closely resembles some of them, besides the general characters of organized bodies, have others which are peculiar to themselves, which consequently distinguish them from vegetables, and which have an influence on, and modify the former. But animals are so very different from each other, that their characters, which may be said to be common, are neither very numerous, nor very distinct. The following are those peculiar to animals, some few of which are common to all, and others are more or less general.

Besides the rounded form which belongs generally to all organized beings, we observe that the greater number of animals are, at least externally symmetrical and divided by a median vertical line, into two lateral and similar halves, and that their length in this direction, is greater than in any other of their dimensions. The liquids greatly predominate over

the solids. The areolar or cellular tissue, which forms the greater part of the body, is very soft and contractile. The body is traversed by an internal cavity, in which the aliments are received. This cavity as well as the exterior surface, is invested with a membrane or skin which limits and envelops the remainder of the body. There are in many animals circulating vessels which convey, in certain determined directions, the nutritive substance found in the intestine, into every part of the body; organs of respiration, in which this matter is submitted to the action of the atmosphere, and secretory organs, in which a part of this matter is separated from the mass. They have genital organs which generally consist in a cavity from which the germs are detached and expelled. Finally, in most animals, there are muscles to execute the apparent movements, senses to receive the impressions of external objects, and a nervous system consisting in cords or filaments, having one of their extremities immersed and expanded in the integuments and muscles, and the other swelling into enlargements or ganglia more or less considerable.

§ 12. The solids, or organs of animals, have for their principal base the cellular tissue, a soft, extensible and contractile substance, easily permeated by liquids. Condensed on the two surfaces of the body, it forms on the exterior, the skin, and on the interior, the mucous membranes or the internal skin. It is this very same membrane, the skin, variously disposed, which constitutes the organs of respiration, secretion and generation. It also forms the senses. Hollowed into ramified canals, in the parietes of which it possesses a considerable consistence, the cellular tissue constitutes the vessels. This same substance variously modified, without losing however its distinctive characters, forms also several other kinds of organs in animals. The muscular fibre constitutes a second kind of solid, essentially differing from the cellular tissue, because in the midst of this soft substance which forms the common mass, linear series of microscopic globules are to be observed; this muscular fibre contracts whenever irritated. The substance of the nerves is formed also of globules, but different from those which compose the muscles; it transmits to nervous

centres the impressions received, and to the muscles the influence of the same nervous centres.

The animal fluids or humours are numerous and in abundance. In most animals there is a liquid in circulation in the vessels; it is the blood, which is the principal and most important part of the nutritive liquids; other liquids are absorbed from the surfaces or the mass of the body itself, and others, finally, are secreted or separated from the blood. This latter essentially consists in a very abundant serous vehicle, in which are immersed microscopic bodies similar to those observed in the solids. The composition of the blood is altogether analogous to that of the solid parts, and a simple change of state, or some small change in the proportions of the componing elements, are sufficient to produce the conversion of the liquids into the solids.

The ultimate anatomical elements of the humours and of the organs of animals, appear then to be simply an amorphous substance, liquid in the blood in which it constitutes the serum or the albumen, and concrete in the organs in which it constitutes the cellular tissue, and a substance under a globular form, or globules freely floating in the blood, and stationary in the organs where they form the muscular fibre and the nervous substance. The chemical composition of the animal body is more complicated than that of vegetables, and consist in more volatile elements. This is the reason why nitrogen enters into their composition as a very essential part, and is mixed with the other general elements of the organization. Lime is the earthy element most generally found in it.

§ 13. The general organic phenomena, such as nutrition and generation, are met with in animals, but modified by the phenomena which are peculiar to them. Nutrition, instead of being the result of external absorption alone, is induced at the same time, and principally from an internal absorption which occurs in the intestinal cavities. The nutritive fluid taken up in the intestines is submitted to the action of the atmosphere; the result of this respiration, is a production of water and carbonic acid, which result is precisely the contrary of what happens in vegetables. Besides this, the nutritive liquid needs

to be continually purified from all superabundant and extraneous substances, by means of secretion. They occur on the external and internal surfaces, sometimes through the gaping orifices of vessels opening on large surfaces, which permit the secreted liquid to ooze out; while at others it is from the bottom of small cavities formed in the skin or in the mucous membrane, that we perceive this percolation; again, we observe the circulating vessels communicating with proper vessels or ramified excretory canals, which are also formed by the envelope of the body, and which pour out the secreted liquid. Among the liquids which are the result of secretions, some are necessary to the exercise of functions, others are entirely rejected as superfluous and extraneous, which constitutes a kind of depuration. The nutritive fluid continually supplied by intestinal absorption, maintained in a proper state by respiration and secretions, is sent into every part of the body, and there effectuates nutrition, a wonderful process in which this fluid is decomposed in such a manner, that in every part of the body a portion of the blood becomes solid, and constitutes an integral part of the organ; when at the same time, and in every part also, a portion of the organs returns to a liquid state, and again enters into the vortex of the circulating fluid. Generation, or the production of a new being, is so diversified in its modes, that it presents no distinctive character peculiar to animals and common to them all. The separation of the sexes, which is subordinate to motion, is in fact, neither peculiar nor common to the animal kingdom. Animals possess also the power of reproducing by a kind of vegetation, certain parts when they are removed, although in a smaller degree than vegetables.

§ 14. Muscular motion, sensations and nervous action, give to animals, in a manner, a new life. These functions have consequently received the appellation of *animal life*, in opposition to the other functions called *organic* or *vegetative life*. The impressions produced by external agents on the organs of sensations, i. e. on the external or internal skin, or in a peculiar manner on some of their organized parts, induce in these organs actions which are transmitted by the nerves to

the central masses of the nervous system. There does not exist a single part of the body, which, under certain circumstances, may not be the seat of some sensation. When the animal has received a sensation, and that excites in him a volition, it is also through the nerves that this volition is transmitted to the muscles, the contractions of which produce the movements of the animal.

The nervous action is not confined to transmitting the impressions received by the senses and the volition to the muscles; for, the nervous central masses are also the organs of instinct and of the cerebral functions.

The functions of which we speak are not only superadded in animals to the organic or vegetative functions, but they singularly modify the exercise of the latter. Thus in nutrition, the introduction of the aliments is generally produced by muscular movements; the muscular fibres which form a coat to the intestines, is also the cause that the aliment they contain is moved on in this tube; it is also a set of muscles, which, in many animals, are placed at the point and centre of reunion of all the vessels, which propel the blood; and it is muscles also which induce, by their movement, the introduction into and diffusion of air in the respiratory organ. There are senses placed at the entrance of the organs of nutrition. Nerves are also distributed to the organs of nutrition, and although in an ordinary state these nerves transmit neither sensation nor volition, and movements are suddenly determined in them by impressions or irritations, nevertheless, in powerful affections of the nervous centres, the movements are interrupted, and in a pathological state these functions are accompanied with sensations. Generation is like nutrition, modified in its actions by the animal functions.

§ 15. There is, in fact, between all the organs, and between all the functions of animals, a connexion which exists in all organized and living bodies, but which is still more remarkable in animals, and especially in some of them. In organized beings, which possess only nutrition and reproduction, the latter of these functions is the consequence of the former. In animals which enjoy motion and sensation, nutrition must

be executed by digestion, for the animal could not at the same time possess the power of locomotion, and be fixed; generation in this case is sexual. In proportion as each order of functions becomes more complicated, the organs superadded to those, whose existence is more general, hold the former under their control. Thus, for instance in the order of the nutritive functions, the circulation, and in the latter, the action of the heart, which is not as common as the other nutritive phenomena, keep, when they exist, all the others under their influence. In the same manner, in the *animal functions*, the action of the nervous centres holds in subjection those phenomena, whose existence is more generally met with in organized beings. The *animal functions* hold under theirs all the *nutritive* and *reproductive* ones, but these latter, in their turn, keep the former in a similar state; the *organs* of *animal functions* having to be nourished, in order to fulfil their own, and these latter inducing the exercise of the *organs* of the *vegetative functions*. So that, in animals whose organization is very much developed, life seems essentially to result from the reciprocal action of the *central organ* of the *vegetative functions*, and from the principal organ of the animal functions, from the circulation and the nervons action, or in other words, from the action of the blood on the nervous system, and from the nervous system on the organs which propel the blood. The other phenomena maintain these two principal actions, which may be considered as the two essentially vital functions of animals.

§ 16. To all these characters, the first very general and common, and the second much less so, we must add the disorders of the organization, and the phenomena of life, i. e. diseases much more frequent in animals than in vegetables; and the reason of this may be easily found in the complication of their organization, in the concatenation of all the parts with each other; and in the operation of central and predominating organs, the action of which can not be disturbed without the whole economy suffering by it. Hence the study of the causes and external bodies which influence the animal organization in a hurtful or beneficial manner, and the art of preserving or

restoring health by the well directed employment of external agents, or the science of medicine.

Such are the most general characteristics of animals; but these beings present in their organs and functions a multitude of varieties or of degrees of complication, that it is important to examine.

§ 17. The external form, or configuration, which may give an idea of the structure, of which it is, in a manner, the outline, presents the following varieties. Some animals are punctiform or globular, as the *monads;* others are filiform as the *vibrio;* some are flat, resembling a small membrane, such are the *cyclida;* finally, others belonging, like the preceding ones to the class of *infusoria*, have no determined form, their configuration changing at every moment in the most singular manner, these are the *protei.* These elementary forms, which pertain to all the animals that are the simplest in their composition, are to be found in some individuals of a nobler order, and in certain parts of all others. The same is the case with the stellated or radiated form which belongs to a certain number of classes of animals, and that we meet with in various parts of those animals which have a very different external configuration.

The radiated form begins to be observed in the order *rotiferæ*, and other *polypi;* in the *acalepha* and *echinodermata*, the radiated form is not confined to their exterior, which resembles a radiated flower, or to a star, but all the parts are arranged around an axis, and on a greater or smaller number of radii. In some other animals the axis being longer, the radiated form becomes cylindrical. The cylindrical echinodermata, intestinal worms and *annelides* establish this passage from the radiated form, of which they still preserve some slight marks, to the symmetrical form and articular arrangement which they likewise possess; and the *tunicata* the transition from the radiated to the symmetrical form without articulation.

The symmetrical form is to be observed, with some few exceptions, in all other animals. In those which have this configuration, the body is divided into two lateral parts, or into

two similar sides by a median line; but it is subdivided into two others very different. In the *mollusca* the body is not divided into segments, and there are no articulated feet, for they are inarticulate. The other symmetrical animals, on the contrary, are articulate, i. e. their body is divided into segments, moveable upon each other, and their limbs, when they have any, are divided into several parts by articulations. We already discover the articular arrangement in the *cirrhipoda*, which properly belong to the *mollusca;* the rudiments of it are also perceived in the *cylindrical echinodermata*, and in worms, but this kind of form more particularly belongs to the *annelides*, *insecta*, *crustacea*, and *arachnides*, which for this reason are called articulated animals, and to all the vertebrated animals. Thus we may in conclusion refer the animal forms to the following: the symmetrical or binary form, with or without articulations, the radiated form, and the simple forms of a globule, of a filament, &c. &c.

§ 18. The external configuration of animals presents also other differences. The body is divided into a trunk, a central part, which contains the organs essential to life, or in other words, the viscera, and into appendages, parts generally destined for motion and sensation. The trunk is divided into the trunk proper, or the middle part, and into the extremities, the head and tail; the trunk itself is sometimes subdivided into abdomen and thorax. The head is the part which contains, besides the mouth, the principal nervous expansion, or the brain, and the organs of the special senses. The thorax, in the *articulated* animals, is the part of the trunk to which the limbs are attached; in the *vertebrata* it is that which contains the heart and lungs. The abdomen always contains the principal organs of digestion and of generation. These various parts of the trunk, which do not all constantly exist, present diverse varieties.

In the *radiated* animals, in the *acephalous mollusca*, and in the *intestina* and *annelides*, the trunk is reduced to its middle part, consists of a single cavity, which contains all the organs. In the *cephalous mollusca* there is a distinct head; the same is the case with the *insecta*, *crustacea*, and *arach-*

nides, which have besides a thorax, sometimes distinct from the head and abdomen, and at others confounded with one or both parts of the trunk. In the vertebrated animals the head is always distinct, but the thorax is sometimes confounded with the abdomen. The appendages present also different varieties; in the *infusoria* there are small ones called ciliæ. The radiated animals have the mouth surrounded with appendages called tentacula, which are destined for motion and sensation. The same is observed in some mollusca, which have sensitive tentacula, and other fleshy productions, called arms or feet, for the purpose of locomotion. The crustaceous animals and insects have antennæ, articulated filaments, of very diversified shapes affixed to the head, and which seem to be organs of sėnsation. The same may be said of their palpi, that are found also in the arachnida. The lateral appendages are double, essentially intended for motion, and are called limbs when they are articulated, the rudiments of them may be observed in the cirrhopoda and in the setigerous annelides; they are found in great number in the myriapoda; they are also found in a considerable, but variable number, in the crustacea; there are eight in the arachnides, and six in the true insecta, which possess, for the most part, either four or two wings. In the vertebràta, there are never more than four limbs.

§ 19. The organs of nutrition present a very great diversity. In the most simple animals, the infusoria, this function consists solely in an external absorption or imbibition, the materials of which penetrates every part of the body of the animal, and is immediately assimilated and afterwards excreted; this simplicity of organization is to be found in some intestinal worms, and in some of the acalepha.

In animals, a degree higher in the scale, we find an intestinal cavity excavated in the substance of the body, and from this moment absorption is performed by both surfaces, and especially by the internal one. This simple cavity is observed in some polypi. At a still higher degree, this cavity consists of a membranous sac, distinct from the mass of the body, formed by a membrane or internal skin, continuous and analo-

gous to the external one. The animals which present the first rudiments of the arrangement, are also the polypi and acalepha and some intestinal worms. In other animals of the same class, the gastric cavity has prolongations extending into the mass of the body, in order to provide it with nourishment. In some acalepha and intestinal worms, the stomach is wanting, and there are only ramified prolongations opening on the external surface. In all these first appearances of an intestinal cavity, that cavity is confined to a mere elongated sac, having one single opening. Several of the echinodermata, and intestinal worms have a distinct intestinal canal, a mouth and an anus, an arrangement which is to be observed in all the higher classes, in which this canal, more or less enlarged, or more or less contracted, is extended through the body. The existence of this canal is perceived at the same time with the cylindrical and elongated form of the body.

The mouth presents several varieties, the principal of which are those of a simple orifice, or an opening furnished with muscles, and sometimes with hard parts, but intended for suction only; or an orifice surrounded with muscles, and furnished with hard parts to divide the aliment.

§ 20. In many of the inferior animals, the nourishing fluid, absorbed by the parietes of the intestines, which are either simple or elongated and extended in the body by ramified appendages, is carried immediately by the areolar substance into every part of it. This is the case with all the radiated animals, and with the immense class of insects. In fact, in no insect are there any vessels, and the nourishing fluid must pass by *imbibition* from the intestine into every part of the body; there is only a dorsal vessel which appears to be the rudiment of a heart, but there are no branches for circulation.

In animals of a still higher class, the nourishing liquid, absorbed by the parietes of the intestines, circulates in close vessels, the minute ramifications of which, only permit the nourishing molecules to pass into the substance of the body. The vessels which go from the centre of the circulation to all the other parts are called arteries; those which bring back the li-

quids from every part of the body to this same centre, are named veins; at the point of reunion of both, is to be found in many animals a fleshy organ, the heart, which aids by its contractions the motion of the liquid, and which, like the vessels, is more or less complicated. We find the first rudiments of vessels in some intestinal worms, and the first rudiment of a heart in insects.

In the annelides, the only invertebrated animals which have red blood, there are arteries and veins for the circulation, but there is simply a rudiment of a heart. In the arachnides tracheariæ, the organs of circulation are not any better marked than in the insects; but in others, such as the pulmonariæ, there is a heart or great dorsal vessel and branches on each side.

The crustacea present more distinctly a heart; in some it is elongated into a large fibrous vessel which extends all along the tail, giving branches on both sides, and which recall to our minds the dorsal vessel of insects; but in other crustacea, there is a dorsal ventricle, a great abdominal vessel, and positive circulatory vessels. In the mollusca there is a heart more or less complicated, a double system of arteries and veins; the blood is white or bluish. Finally in the vertebrata, besides the arteries, veins and heart, there is a particular system of lymphatic and chyliferous vessels which convey the nourishing fluid from the intestines into the veins.

The simplest heart is composed at least of a ventricle which propels the blood into the arteries, and is often accompanied with an auricle or venous sinus at their entrance into the heart; it is called *aortic* when it sends the blood to the whole body, and pulmonary when it sends it to the respiratory organs; it is double when there are two ventricles, which, however, may be separated or united. The heart is simple without auricle and pulmonary, in all the articulated animals which are provided with one. The same is the case in fishes, with the exception of there being an auricle. The heart is simple but aortic in most mollusca; it is triple in the cephalopodous mollusca, in which there are two pulmonary ventricles and one aortic, separated and without auricles. In all reptiles there is one ventricle only, more or less divided by a partition, and

which sends the blood into one single trunk, both aortic and pulmonary; the greater number have two auricles, the batrachia have only one. Finally the heart is double in birds and the mammalia, they have two auricles and two ventricles in contact, one aortic and the other pulmonary.

§ 21. In order that the nutritive fluid may be fitted for its function, it must be submitted to the action of the atmosphere in which the animal lives. In those which have no circulation the water acts on the surface of the body; such seems to be the case with the infusoria, polypi, and acalepha:—the intestinal worms also have not the least appearance of respiratory organs. In another degree of organization, air or water penetrates into every part of the body by elastic canals called tracheæ, and which are lined by a prolongation of the skin. The echinodermata have aquiferous tracheæ; in insects there are two longitudinal tracheæ extending throughout the body, having at intervals common centres from which arise many branches, and which correspond to stigmata, or external openings for the entrance of air. In animals that have acirculation, part of the vessels carries the blood into an organ in which they are subdivided over an extensive surface of the external or internal skin. This surface is salient and is called branchiæ when the ambient element is water, and lungs, and hollow, when that element is air. In order to carry on the branchial or pulmonary respiration, there are generally organs for motion, to put the ambient fluid in contact with the organ. In the arachnides, we find the transition of disseminated respiration, which yet exists in the trachearix, to the local respiration, which occurs in pulmonary sacs. In the crustacea generally, the respiratory organs are projecting branchiæ variously configured. The same is the case with most of the annelides. In the mollusca, generally, we find a very great variety in the organs of respiration. Some breathe the air itself, and have a pulmonary cavity; these are the gasteropodia with lungs; others have projecting branchiæ variously configured; others again have their branchiæ in a cavity into which the water is drawn. In fishes, respiration is branchial; but it is pulmonary in the other vertebrated animals.

Respiration is partial, and circulation simple in reptiles, in which there is only one ventricle and one aorta, of which the pulmonary artery is a branch. In all other animals which have a local respiration and a circulation, this latter is double, and respiration complete; i. e. at every circuit of the blood, the whole liquid passes through the respiratory organs. In the articulated animals and mollusca, the circle is simple; in the former the blood goes from the heart to the whole body, and passes entirely through the branchiæ; the same is the case in fishes; in the mollusca, it goes from the heart to the branchiæ, passing first through the whole body. In birds and the mammalia, the two hearts being joined, the circle is double, or rather, the circuit is crossed, and may be represented by the figure 8, at the centre of which is the heart.

§ 22. The nutritive fluid must not only be submitted to the action of the atmosphere, but must also be freed by the secretions, from superfluous matters. In animals which have an internal cavity, and consequently two surfaces, these two surfaces, in all their extent, serve for the purpose of excretion as well as of absorption. The internal and external skin present also small cavities or particular depressions from which the liquid issues. Finally, even in the animals in which there is no circulation, if some particular liquid is to be produced, the cavities or depressions either internal or external, of the skin, are prolonged and ramified into the body in the form of vessels or excretory canals, and take up from the nutritive fluid, the elements proper for the composition of this liquid. In the same manner, in the animals which have a circulation, the vessels sometimes spread simply over large surfaces, and permit the secreted fluid to escape by perspiration; at others it is from the bottom of small cavities or follicles formed either in the internal or external skin that the liquid oozes; in other parts, the arteries, at the point where the arteries change into veins, communicate with ramified excretory canals which are always formed by the internal or external skin; and from the union and combination of these canals with the blood vessels, result the glands. These last organs of secretion are peculiar to those animals which have a heart The liver, for instance, which is

the most general of these organs, does not yet exist in the arachnides tracheariæ, but under the form of a separated vessel as in insects; on the contrary, in the arachnides pulmonariæ, and in the crustacea, we still find the liver divided into distinct lobes, or as in some, in the form of a bunch of grapes. The mollusca have a very considerable liver; most of them have salivary glands, but neither pancreas nor kidneys. Several have secretions peculiar to themselves. All the vertebrated animals have glands, and in addition to what the others possess, they have kidneys, organs which have many points of relation with those of generation. Among the liquids which result from the various secretions, some have their appropriate use in the exercise of the functions, as saliva, bile, &c.;—others, such especially as the urine are rejected as superfluous and hurtful.

Thus the organs of the nutritive functions in their great diversity, consist in a permeable absorbing substance, which assimilates and excretes; in one or two surfaces, the skin and intestines, which foreign substances have to traverse from without inwardly, or from within outwardly by absorption, or by excretion; in vessels which establish communications between the surfaces of the body and all the parts of its substance, and vice versa; in respiratory organs, which are a portion of the surfaces, where the liquid comes in contact with the atmosphere, and in secretory organs, another part of the surfaces, where a portion of the liquid is rejected.

§ 23. Generation, or the production of a new being similar to the one to which it owes its origin, is the second function in point of importance, common to all organized and living bodies, and presents also in animals a great variety in its organs and phenomena. This function in its simplest state, has no particular organ; but the whole body being very simple and homogeneous, divides itself in several fragments, each of which preserve the properties of the whole mass; this is called the fissiparous generation, it belongs especially to the infusorii, and exists accidentally in others. In some animals of the same class, we observe in the substance of the body globules or corpuscular substances which appear capa-

ble of reproduction, this is the subgemmiparous generation or the first indication of a production of *buds*. In a higher degree of animals, generation is truly gemmiparous, a bud grows on the external surface of the body, and afterwards drops off to form a new being distinct from its parent, or it continues to remain united, and forms a branch of it. This kind of generation belongs to the polypi. The internal gemmiparous or suboviparous generation is also to be met with in theirs. Its organ consists in cavities prolonged in the mass of the body, and in the interior of which grow buds or ovula, which separate spontaneously and issue by traversing a canal which opens on the external surface. This mode of generation is also that of the acalepha, echinodermata, and perhaps in the cestoid intestinal worms. The acephala and some mollusca gasteropoda differ only from them because they have a true ovary. In all those beings, there are properly speaking no sexual organs.

§ 24. In all beings of a higher organization, there are genital organs for both sexes, the concurrence of which is necessary to animate the germ. The female organs consist in a mass of germs or an ovary, and in a canal through which issue the germs when detached; this is called the *oviduct;* and in several species, in a cavity in which they remain for a longer or shorter time, into which they ingraft themselves, and in which they acquire a certain growth before they are born, this is the uterus, and the orifice through which they come into the world, the vulva. The male organs are composed of glands called the testicles, which secrete the sperm, a fecundating liquor, and when this is to be introduced into the body of the female, the male is provided with a penis. In this kind of organization the concurrence of the two sorts of organs is necessary to bring about generation. We find the first rudiments of this organization in some intestinal worms; but these animals being not provided with a circulation, their ovary and testicles simply consist in free or floating secretory vessels. The genital organs are also of two kinds in many of the mollusca, in the annelides and other articulated animals, and in the vertebrata. The ovaries and testicles are glandular masses

only in those animals which have a circulation. Among these, some are hermaphrodite, or are provided with both male and female organs; but this hermaphrodite state is incomplete, or rather insufficient; for in order to engender they require a reciprocal copulation with another similar individual: such is the case with some annelides and mollusca. In a more elevated order of beings, the genital organs are separated and borne by different individuals, and this constitutes the sexes. This occurs in some intestinal worms, in many mollusca, insecta, crustacea, arachnida, and in all the vertebrate animals.

§ 25. In sexual generation, the germ is enclosed with nutritive substances in a membranous or more solid, and even calcarious envelope; then it is called an egg. Sometimes the egg contains nutritive materials in a sufficient quantity to develope completely the embryo, and receives through its coverings the influence of atmospheric air only, and scarcely that of humidity; the animal is then said to be oviparous, either if the egg be laid entire, and the development of the embryo occur after being laid, or if the development precede the laying of the egg, and the egg break at the moment of its birth. In oviparous generation, the germ is only separated, generally, after fecundation; nevertheless, in some instances the germ is separated before, and the egg is fecundated during or even after the laying. The egg does not always contain sufficient materials for the development of the embryo; in that case it ingrafts itself by its surface in the uterus, and absorbs therein nutritive substances; the young one is born living with the remains of its membranous egg, but in a state of weakness which requires to be nourished with an animal fluid that the mother secretes—the milk. The mammalia are alone in this situation. Some young animals, on quitting the egg bear no resemblance to their parent; they experience before reaching their form a change which is called metamorphosis; such are the larva of insects, and the tadpole of the batrachia; the others, on the contrary, are born similar to their parents, or at least there are only some slight differences of proportion, which in time disappear.

§ 26. Nutrition and generation are not the only two modes

of the formation or production of animals; they possess also, although in a less degree or less general manner than vegetables, the faculty of reproducing by a kind of vegetation, parts which have been cut off or destroyed; but the faculty is not even in the same degree in every animal: The simplest animals in organization possess it in the greatest perfection. The polypi, and especially the hydra, always reproduce those portions which have been cut off, so that individuals are multiplied by the simple act of division of parts. The power of reproduction of the actinia is no less extensive; they reproduce parts which have been taken away, and are multiplied by the division. The asterias have also a great power of reproduction; they again produce the rays which are destroyed; even when a single ray, provided it be entire, can reproduce the others.—The faculty possessed by the tœnia of reproducing the posterior rings of their body is well known. Among the annulosa, the nereides has also a very great power of reproduction. Experiments have been performed on the lobster, which went to prove the power possessed by this animal of shooting out a new foot whenever it has been injured by accident. It seems that the arachnides also have the faculty of regenerating legs which they have lost. The aquatic salamanders have also an astonishing power of reproduction; they shoot out several times in succession the very same limb when cut, and that too, with its bones, muscles, vessels, &c. The limbs and tails of the tadpole of the frog is also regenerated very much like those of salamanders. The tail of the sauria, when torn off, grows again, although sometimes a little different from the first one. In warm blooded animals the power of reproducing parts which had been removed by excision, is almost confined to epidermic or horny parts. As to the other parts, this power does not extend beyond the healing of wounds, and the production of a cicatrice analogous to the skin, when this latter is cut off or destroyed.

The organs and functions belonging to animals, present, like the preceding, many degrees of complication or varieties in the beings which compose the animal kingdom.

§ 27. In the simplest animals the body being, or appearing

to be homogeneous, we perceive no particular organ for motion, and nevertheless these infusory animalculæ move about with great rapidity. There are other animals a little more complicated, which are yet unprovided with any kind of distinct muscular organ: such as the rotiferæ, which have a particular rotatory organ, or like the polypi, which have around their mouth tentacula, the movement of which agitates the water, and with which they attract and seize nutritious substances, and some of which possess, besides, movements performed by the whole body. The proper organ of visible motion, the muscular fibre, exists in the acalepha, and in the echinodermata, the muscular system of which is supported by a well organized skin, and in all the more elevated animals in which the apparent movements either general or partial, are produced by the action of these organs. The muscular fibres, in all animals, which have any, supply the external and internal skin: they also form the heart of such animals as possess one. Among animals, some have the skin as soft as the other parts of the body; in a great many, it contains within its thickness indurations, either calcarious, or horny, which shield the animal from external injuries, and which being moveable on each other, transmit to the parts they support, the motion that they have previously received from the muscles.—In the vertebrate animals, this latter office is fulfilled by moveable, articulated, internal bones, and which for this reason are provided with a great mass of muscles which is either wanting in the invertebrata, or is attached on their cataphracted or indurated skin.

§ 28. In the simplest animals, the organs of the sensations have no distinct existence. The whole body seems to receive impressions as it executes movements. In those which have an external and internal skin different from the remaining parts of the body, and all from the polypi upwards, have this arrangement, the skin, besides the function of absorbing nutritious substances, receives the impression of external bodies. In those animals which have a very soft skin and but little different from the other parts, it is every way equally sensitive. But the part of the skin which is moistened in various animals

with mucus or with a sebaceous matter, is in many, provided with an epidermes, hairs, horny scales, or a calcareous crust, and becomes also an organ of defence and support. In this case, some parts are not covered with these envelopes, are very moveable, and constitute particular organs of touch; such are the tentacula of sea-urchins, those of some fish, those of mollusca; the antennæ of insects and crustacea, &c.

The organ of taste is not to be met with, distinctly, in all animals, which digest, and yet it seems requisite that this sensation should exist in all. In the radiated animals, nothing is to be perceived, at the entrance of the alimentary canal, which seems to be that organ. The same is the case with respect to the mollusca and articulated animals. In some insects, however, this faculty is supposed to exist in the extremity of the proboscis or palpi; finally, all the vertebrata are far from having a tongue organized in a manner to enable them to taste.

The organ of smell seems to be wanting in a great number of animals; insects, however, crustacea, and arachnides are sensible to odours, but the precise seat of their sensation is entirely unknown. The same may be said with respect to the mollusca. Even in the vertebrata the nasal fossæ do not traverse the face in all the classes.

The organ of hearing or the ear is not found in the lower classes of animals, and sound seems to be only perceived as a tactile impression. Among articulated animals the crab is the only one in which we observe an ear, though they all hear very well. The ear in the crab consist of a bag filled with a gelatinous lymph, which receives a separate nerve. In the same manner, the mollusca and cephalopoda have this organ, which exists in the vertebrata, and which presents a great variety.

Light has also an action on the skin of all animals, and on every part exposed to its influence; but the faculty of sight is possessed only by those who have its organ, the eye. The radiated animals have no eyes. A portion of the annelides are deprived of it; in the others we only meet with the rudiments; it is a mere black spot. The articulata with feet, viz: the crustacea, arachnides and insecta, have all eyes which may be of two

kinds, more or less numerous, and always symmetrical; viz. simple eyes, the cornea of which present only one facet, the iris only one opening, and the optic nerve a single filament, and compound eyes, or with many facets with as many pupils and with as many filaments of the optic nerves. Sometimes the eyes are pediculated or placed on articulated appendages. The acephalous mollusca are deprived of eyes; most gasteropoda have them, but small and rudimental, placed either on the head or the posterior tentacula. The cephalopoda have two large eyes covered with a transparent skin. In the vertebrated animals, the eyes are wanting in a very small number of species.

§ 29. The nervous system is unknown and seems not to exist in the infusorii. The first rudiments of it are to be observed in the radiated animals. The Hydra, among polypi, possess microscopic globules the nature of which is uncertain. But in the sea-star and in the Holothuria there are ganglia arranged in a circular form around the mouth, communicating with each other by soft filaments, distributing others in a radiating manner to the different parts of the body, where some are conveyed to the external, and others to the internal skin. In some intestinal worms we observe a nervous ring around the mouth, whence arise two cords which extend the whole length of the body. In the articulated animals the nervous system presents a tolerably general character. There is a little enlargement placed on the æsophagus called brain, furnishing nerves to the parts which are connected with the head. Two cords, which encircle the æsophagus like a necklace, extend under the intestinal canal, and unite at intervals, forming as many double ganglia or knots as there are rings in the body; thence arise the nerves of the trunk and those of the extremities when any exist. The arrangement is nearly the same in the cirrhipoda. In the mollusca there is a greater variety than among the articulated animals. These means of communication, however, are ganglia united by cords, and conveying filaments to the different external and internal parts. In the acephala there is above the mouth a principal ganglion, improperly called brain, and another at the opposite extremity

of the body; behind the intestines, two nervous branches establish a communication with the various ganglia, and embrace in their lateral extension, the viscera; other filaments are distributed to the different parts of the body. In the mollusca provided with a head, there is a nervous enlargement or a principal medullary mass called brain, situated across and over the æsophagus which it envelops with a nervous ring, which terminates underneath in another but larger ganglion: these enlargements send filaments to the head and to the various parts of the viscera. In some of them, there are besides other small ganglia. The cephalopoda alone have their brain enveloped in a kind of cartilaginous cranium.

The general character of the nervous system of the invertebrate animals, particularly consists in the dissemination of the nervous centres, and in the circumstance that the parts either external or internal, or those which belong to the vegetative functions, or those which belong to the animal functions, receive their nervous filaments from the same centres. We shall see, on the contrary, that in the vertebrata the nervous system is differently disposed, and in a manner which entirely distinguish them from other animals.

§ 30. Nervous action or innervation, presents in animals varieties corresponding to those which are observed in the disposition of the nervous organs. In those animals which have no nervous system, and in those in which this system has no centre, (the radiated animals,) impressions are immediately followed by movements; a part or an animal is called irritable whose movements are produced by impressions. In the radiated animals the mouth or the orifice through which they take their nourishment is the most irritable part; it is also at this place the nervous system begins to appear in animals of this class provided with it. All other animals have also irritable parts. In the mollusca and in the insecta in which the divers ganglia of the nervous system are connected with each other by nervous cords, in such a manner as to form a centre, and in which there are organs of a special sensation, the impressions received by the senses produce sensations, and the movements are caused by volition. The internal movements,

however, are produced by irritation, but irritability in these animals is dependent upon the nervous system. We also observe in them, and especially in insects, a faculty called *instinct*, and which, like an irresistible impulse, causes them to produce, without being taught and without imitation, very complicated actions, that are necessary to their preservation and to that of their species. The vertebrated animals besides irritability, sensibility, voluntary movements and instinct, have cerebral functions which, to a certain degree, resembles intellect.

§ 31. The varieties or the degrees of complications which exist in each apparatus or function, are combined in various modes, which constitutes the varieties of the general organization. The combination or the coexistence of the various apparatuses of organs is determined; a certain state of the nutritive or genital organs requiring, for the support of life, some corresponding state of the organs of motions, of sensibility, &c. According to a well defined distinction of organization, animals are divided into vertebrate and invertebrate. Man belongs to the former of these divisions.

§ 32. Although the invertebrata differ greatly from man, their study is nevertheless of great utility to the anatomist and physiologist; we observe in them organization and life in their greatest simplicity, and under a multitude of varieties. They differ so much with each other, that they have no common and positive character. According to their organization, they are divided into three great sections which differ from each other as much as they are unlike the vertebra: these are the radiated animals, the mollusca, and the articulata; and we find even besides these three divisions, a class of very questionable beings that zoologists describe under the name of infusorii, and which botanists claim as belonging to the conferva.

§ 33. These dubious and microscopical animals, have a very simple organization, different forms, and sometimes changeable; they are homogeneous, transparent and diffluent; they have no cavity, no distinct organ; they move, however, in the water

which contains them, are nourished by imbibition, and multiply by spontaneous division.

§ 34. The radiated animals constitute a particular type, the essential character of which consists in the form, which is, a centre around which the other parts are arranged like the spokes of a wheel. Their structure, rather simple, presents several varieties from the simplest among them, the hydra or polypus with arms, to the asterias or sea-star. They all inhabit the water.

§ 35. The polypi form an extremely numerous class of radiated animals. They are generally elongated, having one single orifice or mouth furnished with radiating appendages; they have an alimentary cavity, digest very quickly, and absorb by imbibition, produce buds which sometimes remain adherent and form complicated phytoid animals, and at others separate. The external and internal surfaces are alike; the intermediate substances are homogeneous and gelatinous; no peculiar organ is observable, except microscopical globules, and they possess in a high degree the power of reproduction, for when divided, each part becomes an individual. Light, noise, and other exterior causes, produce on them impressions followed by motions. Some are fixed to the ground, others are free. The simplest of all are those which are necked, as the hydra, &c.; they have a simple alimentary sac, and multiply by external *buds*. Others again which are united, excrete from their external surface a horny or calcareous substance called *polypier.** Finally, in others, which are complicated animals, the common body envelops a secreted substance, the consistence of which varies from that of jelly to that of stone.

§ 36. The acephalous animals or sea-nettles (*medusæ*,) have a still more circular or radiated form; they are compared

* Under this appellation are grouped the calcareous substances &c. known under the name of madrepore, coral, &c. which are the excretions of the polypi here alluded to and serving them for habitation. These calcareous excretions are comprehended by the French under the general designation of *polypier*, for which there is no adequate term in the English language.

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to rosaceous or radiated flowers. Their structure is various, for some are as simple as the most simple polypus, and others are much more complicated; the mouth is central, furnished with tentacula, leading into a stomach, often ramified, but which has no other issue. There are for the purposes of generation, a number of oviform internal buds in particular cavities.

§ 37. The echinodermata are the radiated animals, the organization of which is the most complicate: the class contains the stellated, the spheroidal and the cylindric forms. They have an internal cavity in which distinct viscera float; their intestine has vascular like prolongations ramified through the body. Some have a distinct anus; the organs of respiration are ramified aquiferous canals; the organs of generation are oviform masses of internal buds, which terminate either at the mouth or at the anus; they have muscles, and in the greater number there are particular organs of locomotion, consisting in numerous tentacula terminating in the form of a cupping glass, called feet; the skin is well organized, and often solid; some have even nervous filaments.

§ 38. The *articulated* animals constitute a division of the animal kingdom in which the body is symmetrical, divided externally in a certain number of rings or moveable segments, and formed by the skin, more or less tough and sometimes hard, except between the intervals of the rings in which it always retains its softness and flexibility. Their muscles are connected with the inside of the skin; their nerves are cords with enlargements at intervals, situated beneath the intestinal canal. This type however comprehends extremely varied organizations. Some are vermiform, without head and articulated feet, and can only creep: these are the worms and the annelides.

§ 39. The intestinal worms, or the helminthia, which bear some general resemblance to the radiata, have the body commonly elongated, cylindrical or depressed, naked and soft; they have no organ either of respiration or circulation. Their generation is internal, gemmiparous, and sexual, oviparous; they inhabit the bodies of other animals, and present otherwise very dif-

ferent degrees of organization. The simplest of all, the cestoid species, the ligula, resemble a long striated ribbon, marked with a longitudinal line. No external organ, not even *suckers*, are perceived on them, and nothing internally, but oviform corpuscules in the mass of the body. Others again, whose forms are much varied, such as the trematodes and tenioides, have only on the exterior a greater or smaller number of *suckers*, sometimes ramified in the body, which present other canals, either gemmiferous or ovariferous. The acanthocephali echinorhynchi have a proboscis armed with hooks, furnished with muscles; they have two little cœca, and also either distinct oviducts, or spermatic bladders, according to the sexes, which are separated. The nematoides, as the ascarides, &c.; are still more complexly organized; they have a mouth and anus, and an intestinal canal floating in a distinct abdominal cavity; their external skin is furnished with muscular fibres, in general, transversely striated. They have distinct genital organs consisting of long canals. The sexes are separated. They have a nervous ring which surrounds the mouth, and two long cords, one dorsal, the other ventral; they have also two spongy, lateral vessels.

§ 40. The annelides or red blooded worms are vermiform animals, whose elongated bodies are divided into numerous rings, the first of which, called the head, differs but little from the rest; the mouth is either a mere tube or jaws. There is an intestine longer or shorter, which traverses the body; there is a double system of arteries and veins, without any well defined heart; the blood is red, the respiration branchial. They are hermaphrodites, with a mutual copulation, they have muscles, and the greater number, stiff bristles serving for feet; the head is furnished with tentacula, and some of them with black points that are considered as eyes; the nervous system consists in a knotty cord.

§ 41. The other articulated animals, are all provided with a head, and have all eyes, either simple or compound; their very complex mouths, greatly resemble one another, and present two modifications: in the first, for the purpose of grinding, there are several pairs of lateral jaws, the anterior of which

are called mandibles and often palpi, articulated filaments, which appear to serve in recognizing their food: in the second, there is a proboscis for suction. The organs of digestion are complicated and various. They enjoy the sense of smell, but its seat is not well determined. They have all an abdomen, and a thorax which supports six articulated feet, at least. Their skin is encrusted and solid, each articulation of the feet is tubular and contains the muscles of the succeeding one. All the articulations of the feet are by gynglymus; generation is sexual and oviparous. This section contains three great classes, that of insects, the arachnides, and the crustacea.

§ 42. Insects, or the hexapoda, have the body composed of segments or numerous rings, and divided into three principal parts, six articulated feet, a distinct head furnished with eyes, and two antennæ, a thorax which supports the feet and wings, when there are any, and an abdomen which contains the principal viscera. The mouth is very complex, in the *grinders*, there are lateral jaws, in the *suckers* there is a proboscis. The intestinal canal more or less long, enlarged, contracted, &c., terminates by an anus. There is a vestige of a heart in a vessel attached along the back, divided into segments by strangulations, and which experiences alternate contractions. The fluid it contains is white, and appears to penetrate it, like the rest of the body, by imbibition. Respiration is effected by means of ramified tracheæ united in two principal trunks. The secretory organs consist in long spongy vessels or canals, doubling on themselves, running through the mass of the body, and ending either in the intestine or elsewhere, according to the uses of their products. The sexes are separated most frequently, the genital organs terminate in the anus. These animals copulate but once in their life. The impregnated female deposits her eggs in a suitable spot, and the eggs produce vermiform animals called larvæ, which changes into a chrysalis, a state of apparent death; and from which emerges the perfect insect that soon propagates its species and dies. This considerable change of external form, accompanied by others more or less great in the structure, is called a metamorphosis; all insects, the thysanoura and the parasitica excepted, which by their

resemblance to mites, approximate to the arachnides—undergo it; some of them however do not suffer this change in all its extent, and it is then called imperfect. The organs of motion are the muscles and the skin, hardened by a horny substance contained within its thickness; there are six articulated feet, and generally four wings, some have only two, while a very small number are apterous. Their motions are greatly varied, and consist in the walk, running, jumping and flight. The organs of the sensations are compound eyes, and in many simple ones, generally three in number; antennæ and palpi. They enjoy both hearing and smell, but their organs are unknown. The disposition of the nervous system is indicated in § 28, and terminates anteriorly by a little enlargement or brain, situated on the œsophagus, and is distributed to the eyes and other parts of the head.

§ 43. The arachnides or octopoda, whose head, deprived of antennæ, confounds itself with the thorax, have eight feet and no wings. The alimentary canal begins in the one by a mouth with two lateral mandibles, in the other by a mouth fitted for suction or by a proboscis. The greater number have palpi, are subject to moults or a changing of skin, and not to a metamorphosis. The sexes are separated, generation is oviparous, and they have generally visible eyes, which vary in regard to number and situation.

They present two degrees of organization; the first or simplest is that of tracheal arteries, where there are no organs of circulation more apparent than in insects; the organs of respiration are distinct branching tracheæ. The most complex is that of the pulmonary or branchial arteries, (spiders, tarantulæ and scorpions.) They have a simple muscular heart, dorsal, elongated, cylindrical, branchial or pulmonary, whence are derived the vessels for the respiratory organs, which are pulmonary sacs, and thence distributed to the whole body. There is also a liver composed of lobules or grains, collected in clusters. The sexual organs are double in each sex. Some of them copulate repeatedly and live several years; the scorpions are ovoviviparous.

§ 44. The myriapoda or centipedes form a little group of animals, intermediate to the crustacea which they resemble by

their form, and to insects which they approach in structure, still differing however from both. Their body is elongated, and formed of a generally considerable number of rings, each having one or two pairs of feet. The head is furnished with antennæ and two eyes. Their jaws and mandibles are analogous to those of the crustacea. Their respiration is tracheal. On quitting the egg, the young have six feet and seven or eight rings, the other rings and feet which support them being developed by age.

§ 45. The crustacea are of all the articulata with articulated feet, the most complex in their organization. The head and the rest of the trunk are sometimes confounded, and at others distinct, they have a tail more or less elongated, divided into segments, and commonly four antennæ. The greater part of them have the mouth fitted for grinding and for that purpose are furnished with several jaws, at least six, always lateral. There are always at least five pairs of feet for motion, whose forms vary according to the kind of movement to be performed. The number of locomotive feet is in an inverse ratio to that of the jaws: in fact the anterior feet approximate to the jaws, in taking their form, and in filling a part of their functions, they can even completely take their place. For respiration they have pyramidal lamellated filamentous and tufted branchiæ, generally adhering to the base of some of the feet, or which they even partly replace. Their circulation is double; the blood that has been submitted to the respiratory action, is poured into a great ventral, aortic vessel, which distributes it to all the body, whence it returns by another great vessel or even a true dorsal ventricle, which transmits it to the branchiæ. They possess a liver, more or less divided, sometimes even into distinct canals, according to the state of the heart. Generation is sexual and oviparous, without a true metamorphosis. The greater part carry their eggs with them, and they all inhabit the water. They present otherwise a great variety of organization. The jaws, the feet and the branchiæ are so nearly allied, that these appendages have all been considered as being of one kind, the first resulting from a transformation of the last. The greater part cf them have a shell

more or less solid than the rest of the skin, which covers the trunk, and in some even the head. In several orders, the stomach, which is highly muscular, is provided with a cartilaginous skeleton and with tubercles or teeth. The intestinal canal is commonly short and straight. The position of the genital organs varies; in some genera these organs are double. The eyes offer much variety, and in a few are wanting; in others they are very nearly joined, and seemingly thrown into one; some again have compound eyes, supported by a moveable pedicle. Finally, in some of the crustacea decapoda, there are distinct organs for hearing.

§ 46. The *mollusca* form a division of the invertebrata, in which we generally find a symmetrical or binary form, but no articulations. Their stomachs are simple or multiple, sometimes furnished with hard parts, and their intestines variously prolonged. The greater part have salivary glands, all a voluminous liver, and many peculiar secretions. Their circulation is double, and there is always at least one fleshy ventricle which is aortic, and receives the blood from the organs of respiration and sends it back through the arteries of the body. In those that have more than one ventricle, they are not united in one single mass, but form several distinct hearts. The blood is bluish. The organs of respiration are sufficiently diversified to enable some to respire air and others water. Generation also in them presents all its varieties; some not having the sexes and producing living young ones without copulation, and others being hermaphrodites with a reciprocal copulation, while in a third the sexes are separated. The eggs of the latter are simply enveloped with a viscous matter, and others again have shells more or less hard. These animals are very prolific and very tenacious of life. Their muscles are attached to the interior of a soft and elastic skin, and their movements are produced by parts that have no solid levers. They are highly irritable. Their naked skin is covered with a mucous fluid that oozes from it. Almost the whole of them have a development of the skin which covers up the body like a mantle, variously diversified, however, as to figure. This mantle sometimes remains soft, but most frequently it hap-

pens that one or more plates, now and then horny, but oftener calcarious, is formed in its thickness. This substance is ordinarily sufficiently large to enable the animal to cover itself completely with it: this is what we call a shell. Many are deprived of eyes, some have rudimental ones, and those of others are highly developed. Their nervous system consists in medullary masses dispersed throughout the body, the chief of which is situated across the œsophagus, which it surrounds with a nervous circle. They have but little instinct, and for the most part inhabit the water. Besides this they present several differences of organization, some assume that of the radiata, others that of the articulata, and a third by the complex nature of their organs approximate to the vertebrata.

§ 47. The acephala without shells or the tunicata have some resemblance to the radiated animals. Some are collected in one common body, like polypi; among them some are disposed in a star, the anuses being in the centre, and the mouths at the circumference; others form a cylinder in which end the anusses, the mouth opening externally, while others have the viscera prolonged in a common mass, and the radiated mouth and the anus approximated towards the free extremity of the body. A fourth kind only remains united, long after birth: these when they are separated exhibit the form of a contractile tube open at both ends, and in the thickness of which are placed the viscera. Finally, there are others fixed to rocks, which resemble two tubes, the one enclosed within the other, and between whose parieties they cause the water to pass. They all possess an alimentary canal with two openings, branchiæ, a liver, heart and ovaries or internal *buds*, which, without copulation, produce living young ones; they have all ganglions and nervous filaments.

§ 48. The cirrhopoda constitute a small group of animals, intermediate, between the mollusca and the articulata. Their short body without a head and transverse rings, is furnished with a tunick and multivalve shell which resemble those of the acephala; the mouth has lateral jaws, and along the belly there are articulated appendages with a horny skin, disposed in pairs, resembling the natatory feet of the tail of

certain crustacea, called cirri. The stomach is provided with little cells which appear to perform the office of a liver; the intestine is simple; there is a dorsal heart and lateral branchiæ, also a double ovary or a mass of internal *buds* and a double serpentine canal for the exit of the young. These animals are sessile or pediculated, but always fixed; their nervous system is a series of ganglions under the belly.

§ 49. The acephalous or conchyferous mollusca, have the body deprived of a head, containing all the viscera and are completely enveloped, (like a book by its cover) by the mantle doubled in two, and by a calcarious shell, generally bivalve, sometimes multivalve. The mouth is armed with tentacular leaflets concealed under the mantle; the anus is hidden in the same manner; at the other extremity there are four very large branchial leaflets; the liver is very voluminous, embracing the stomach and a part of the intestine which greatly varies. The foot when it exists is attached between the four branchiæ, and consists of a fleshy mass, which moves like the tongue of the mammalia. The heart is commonly single, aortic, and placed near the back. They have one or two muscles for closing the shell and an elastic ligament which opens it; they have also a principal ganglion situated above the mouth, united to another opposite by two nervous cords, and some other nerves and ganglions. They produce living young ones without copulation.

The branchiopoda, are other acephala, but few in number, which in place of feet have two fleshy arms; they appear to have two aortic hearts, and a convoluted intestine surrounded by the liver; neither their generation nor their nervous system is well understood.

§ 50 The gasteropoda are cephalous mollusca that generally crawl on a fleshy disk placed under the belly, the back being covered by the mantle that varies in length and figure, and producing most commonly a univalve or multivalve shell. In this class are to be found some mollusca whose organs of respiration and shell are not symmetrical. The head, placed forward and more or less disengaged from under the mantle, possesses generally two, four, or six tentacula, situated above the mouth, that perform the offices of feeling, seeing, and perhaps

smelling. Most commonly there are small punctiform eyes, belonging to the head or tentacula; the organs of digestion are very varied, and there is never more than one heart, which is aortic: in those that are not symmetrical, it is on the left side for the greater number, and in those that are, on the right. The respiratory organs vary greatly; the greater portion of them have branchiæ, and some breathe air. The same variety exists in their modes of generation, being unisexual without copulation, hermaphrodite with a mutual coitus, and separate sexes.

The pteropoda consist of a small group of mollusca between the acephala and the cephala.

§ 51. The cephalopoda, form a small class that comprises the inarticulated animals the most complex in their organization, and which, like the crustacea, among the articulata, approximate the most to the vertebrata.

They are soft animals, whose bodies are wrapped in a sac formed by the mantle, the sides of which project more or less in fins; through its opening passes a round head, crowned with feet or fleshy arms, provided with suckers which serve for walking, seizing, and swimming. The mouth, situated between the bases of the feet, is armed with two strong jaws of horn, resembling the beak of the parrot; there is a tongue that bristles with horny points; an œsophagus swelled into a crop, a second muscular stomach like a gizzard, and a third one that is membranous; a simple and short intestine ends in the opening of the sac before the neck. There is a double system of veins and arteries, two branchial and one aortic ventricle. The respiratory organs are two branchiæ, situated in the sac where the water for breathing comes and goes. The liver is very large and discharges the bile by two ducts into the third stomach. These animals have a peculiar black secretion produced by a gland and deposited in a reservoir. The sexes are separate; there is an ovary, two oviducts, that take and convey the eggs thence out of the body through two large glands that envelop them with a viscid matter, and unite them in clusters; there is a testicle and a vas deferens which ends in a fleshy penis by the side of the anus, where terminate also a vesicula seminalis and a prostate. Fecundation is performed, it is presumed, by

moistening the eggs. The eye is formed by numerous membranes, and covered by the skin, which at this place is transparent and which is sometimes so doubled as to form folds or eye-lids. Each eye has a large ganglion giving rise to innumerable nerves. The ear is a small simple cavity, sunk on each side near the brain without any external canal, where a small membranous bag is suspended that contains a little stone. The brain is contained in a cartilaginous cavity which is a rudiment of a skull.

§ 52. Such is the immense series of invertebrate animals. They constitute, as we have seen, three different types. We have also seen that in each type there is a general resemblance, and also different degrees of complication and perfection in their organization.

The radiata are evidently the most simple. Through some of their number they approximate to the infusorii. Even the most complicated among them have yet no central organ of circulation, and no predominant nervous one: destitute of central organs, they have no organic or vital unity.

After the radiata come the mollusca and the articulata. As to the order of organic superiority of these two divisions, it is difficult to determine, for on the one hand, if the articulata are inferior to the mollusca as regards the vegetative organs and functions, since many of them are deprived of a true circulation, a function existing in all the mollusca, on the other, the latter are inferior to the former in the development and approximation of the nervous masses, and above all in that instinct which is so perfect in some of the articulata, as to bring them near to the vertebrata.

OF VERTEBRATE ANIMALS.

§ 53. Vertebrate animals, or as they are termed, the *vertebrata*, form a type or mode of organization, to which man and those animals that most resemble him belong. They resemble the invertebrate in the organs of the vegetative functions, while they widely differ from them in those of the animal functions. Their external conformation, with the exception

of almost one genus, is perfectly symmetrical, i. e. that their organs of sensation and motion are disposed in pairs on the two sides of an axis or of a median line. They attain a great size, and it is among them that we find the largest animals, which is owing to the bones that sustain the soft parts. Their bodies are composed of a trunk, and with very few exceptions, of limbs. The trunk is upheld in its whole length by the spine, a column formed of moveable vertebra placed one on another, at one of whose extremities is the head; while the other is generally prolonged into a tail. This column, partly solid, is pierced by a canal which contains the spinal marrow. The head is formed by the cranium which contains the brain, and by the face which consists of the jaws and the receptacles of the senses. The remainder of the trunk forms one or two great cavities which contain the organs of the vegetative functions. In most of them, on the sides of the column, are bony arches, or ribs, that protect the great splanchnic cavity, and in the greater number, these ribs are articulated in front with the sternum. The limbs never exceed in number two pairs, sometimes one, sometimes the other of these are wanting, occasionally even both: in other respects their forms are varied according to their destined relative movements.

The vertebrata have all two horizontal jaws, most commonly furnished with teeth, hard bodies analogous to bones in their chemical composition, and to horns in their mode of formation. In such as have no teeth (the bird and tortoise) we find a true horny matter in place of them. In all the vertebrata, the intestinal canal, extended from the mouth to the anus, and presenting several enlargements, is furnished with secretory glands viz: the salivary glands, the pancreas, and the liver. All have arteries, veins, a heart variously formed and chyliferous and lymphatic vessels. The blood is red. In one class only (Fish,) are there branchia, in the remainder the respiratory organ is lungs. Respiration is more or less great or perfect according to the class. The organ for secreting bile, the liver, receives in all the vertebrata, blood brought from the intestines and the spleen by the vena-porta. They have all kid-

neys, that secrete the urine, and the greater portion a bladder or resevoir for this excrementitious humour. The sexes are always separate; the female has one or two ovaries from which the eggs detach themselves. The male fecundates them with the spermatic fluid, but the mode of impregnation as well as other phenomena of generation, greatly varies.

The muscles, independently of those that form the heart, and those that belong to the skin, the mucous membrane and the senses, are very numerous, and are inserted into internal bones, moving on each other. All such as have lungs, have also a larynx, although all have not a voice. The senses consist of two eyes, two ears, the nose, the tongue and the skin; this membrane being besides provided with several protecting parts, but it is essentially the nervous system which peculiarly distinguishes the vertebrata. In the invertebrate animals the same nervous enlargements, more or less separated, send filaments indifferently to the organs of the animal, as well as the vegetative functions; here, on the contrary, besides those ganglions whose filaments are restricted to the organs of the vegetative functions, there is a particular centre with which these enlargements communicate, and from which originate or where terminate the nerves of the organs of sensation and motion. This centre, perfectly symmetrical, consisting of a thick cord enclosed in the spine, is extended into the cranium, where it presents various enlargements, and is surmounted by two complex nervous organs, called cerebellum and cerebrum. This nervous centre is enveloped by bones firmly united with each other, that defend it from external injuries. This function of the bones may be regarded as one of the most important they possess.

§ 54. Besides the kinds of humours and organs common to all, or at least to the generality of animals, some are found among the vertebrata, which have no existence in the others; these are the red blood, the lymphatic and chyliferous vessels, bones, ligaments and tendons, and the serous and synovial membranes.

In all the invertebrata, the nutritious liquid is of one single colour, and that white or bluish, if we except the annelides

where it is red. In the vertebrata, on the contrary, the arteries, veins and heart contain red blood, a fluid composed of colourless serum, in which corpuscules float, formed of a central globule and a coloured envelope. Its composition is more complicated than in the invertebrata. A whitish or slightly coloured liquid is contained in the chyliferous vessels, which commence at the intestine, and in the lymphatics which arise in every part of the body, both of which are very analogous to veins, and terminate in them.

The bones are hard parts, proper to the vertebrata. They are situated internally and are of an organic nature, consisting in a compact mass of cellular matter, containing a large proportion of the phosphate of lime. They serve as envelopes to the nervous centres; they receive and transmit the muscular motions, and finally serve as support to all the parts, and thereby determine the form of the body. In the invertebrata, the hard parts, in general, are exuded on to the surface of the skin, and consist of shells, crusts, and scales of carbonate of lime, or a horny substance. This latter kind appears again in the vertebrata, where it is variously disposed, as in horns, scales, feathers and hairs, parts all analogous to each other, both in their composition and mode of formation. We also find in the vertebrata a kind of organs which is almost peculiar to them; they are the tendons which connect the muscles with the bones, and the ligaments which surround their articulations; these liens or ties are formed of very highly condensed cellular membrane, whose whole function consists in their tenacity.

The serous and synovial membranes are also parts formed by the condensed cellular substance, disposed in the form of sacs with contiguous parietes wherever the continuity of the parts is interrupted; in the splanchnic cavities it separates the viscera from their walls, in the moveable articulations they contain a liquid which lubricates the adjoining extremities of the bones.

§ 55. But what distinguishes the vertebrata, is not only the actions of the organs proper to them, viz: a more concentrated nervous system, whose central parts are more voluminous, whence results an appearance of intelligence which distin-

guishes itself from instinct, a certain capability of instruction, &c.; it is not only the influence these organs hold over the others, in order to direct their action, but it is, above all, the concentration of life in the central or predominant organs—in the heart, in the nervous centre, and in the action of these parts on each other. Even in this point of view, however, there is a great difference among the vertebrata.

§ 56. The vertebrate animals which are so much alike in most of their characters, present, in fact, a very considerable difference. The similitude is particularly strong in the central part of the nervous system, and in its envelope, that is to say, in the spinal marrow, and spine; and their differences in the extremities and at the surface, as in the brain, the cranium, the organs of sense, the face, the organs of motion, the members, and skin. In the same way, among the organs of the vegetative functions, the heart presents many differences, but they are particularly great in the organs and phenomena of respiration; and as the action of the muscles and of the nervous system depends greatly on respiration, variations in this function occasion corresponding ones in the animal function. Thus in the mammalia, where the circulation is double, that is, where all the blood brought from the body is sent to the lungs before returning to it, and where respiration is aerial, the muscular action is strong. In birds, where the circulation is double, and where respiration is aerial also, is not confined to the lungs, but extends itself to various parts of the body, the vigour of the muscles is still greater; in reptiles, where the circulation is simple, and respiration consequently partial, it is weak and the movements slow, since a part only of the blood is submitted to the action of the air, previous to its return to the body. Fishes, it is true, have a double circulation, but their respiration can not be complete, on account of the small quantity of air contained in the water they respire, consequently, as to station, they are nearly in a state of equilibrium in water. Animals of the first two classes have much warmer blood than those of the two latter, which on this account are called the cold blooded vertebrata.

Their mode of generation, presents also a remarkable differ-

ence, from which the vertebrata are divided into oviparous and viviparous or mammalia.

§ 57. The oviparous vertebrata, are particularly alike in their mode of generation, they have also some common characters of organization in the nervous system, and in the bones which envelop it.

Oviparous generation consists essentially in the germ being inclosed in its envelopes, with nutritious matter sufficient to nourish it until it be hatched, so that if the egg remain in the interior it does not attach itself to the parietes of the oviduct, but remains separate. The nutriment of the young one is contained in a sac which is a part of its intestine, and which is called the yolk. The germ is at first a mere imperceptible appendage, but as fast as it receives its nourishment, it increases in size by the absorption of the yolk which is proportionally diminished, and finally disappears near the period of hatching. The embryos of the ovipari with lungs, birds, and, except the batrachians, reptiles, have moreover a very vascular membrane, which appears to assist in respiration, and which is a prolongation of the bladder: it is called the allantoid; it is not found either in fishes or the batrachian reptiles, whose young are pisciform. Particular fish and reptiles retain their eggs within them until the time of their hatching; such are called ovovipari.

The prolongation of the spinal marrow in the cranium, presents in the ovipari, highly developed tubercles, called the quadrigemina; the cerebrum and cerebellum, on the contrary, are very slightly so, and there is no pons varolii nor corpus callosum. The bones of the cranium are either very quickly consolidated, or remain a long time divided; their senses are not as perfect as those of the vivipari; the lower jaw, which is very complex, is articulated by a concave facette with a projecting part of the temporal bone, that is distinct from its petrous portion; the orbits are only separated by a membrane or a bony plate of the sphenoid. When they possess anterior members, the clavicles unite and form a fourchette (as the merry-thought of a chicken) while the elongated coracoid apophyses are articulated with the sternum. The larynx is sim-

ple, and has no epiglottis &c., neither is there a complete diaphragm between the breast and the abdomen.

The ovipari are divided according to their mode of respiration, their temperature, the atmosphere they inhabit, their motions, the appendages of the skin &c. into three classes: Fishes, reptiles and birds.

§ 58. Fishes are evidently organized for natation; they are suspended in a fluid nearly as heavy as themselves. Many, under the vertebral column, have a bladder filled with air, which by its own contraction or dilatation varies the specific gravity of the animal. The head variable in its form, is of a very complicated structure, as regards the cranium, the jaws, and the distribution of the teeth. The limbs are abbreviated and formed into fins; other fins occupy the back, the top of the tail and its extremity. The number of members varies, most generally there are four, sometimes only two, and in some they are totally wanting. Their position and connexion with the trunk also vary greatly, so do the organs of digestion; the pancreas is generally superseded by intestinal appendages. The circulation is double, i. e. all the blood passes through the respiratory organs, but the atmosphere respired is aerated water: for this purpose, they have on the sides of the neck, an apparatus of organs called branchiæ. These are leaflets attached to little lateral arches of the os hyoides, and composed of numerous membranous laminæ, covered by a net-work of numerous blood-vessels; this opening, is, besides, furnished with a branchial membrane, supported by the processes of the hoyoideus and a bony operculum. The water which the fish compresses in its mouth as if to swallow it, escapes between the divisions of the branchiæ and acts on the blood. The heart has only one auricle, which receives the veins of the body, and one branchial ventricle. The blood, after having traversed the branchiæ, is directed into a large vessel under the spine, which, exercising the functions of ventricle and aorta, transmits it to every part of the body.

Fishes have elongated kidneys stretched along the sides of the spine and a bladder. Their testicles are two enormous glands, generally known by the name of milts, (*laite*) their

ovaries are not less voluminous; most of them first lay their eggs, and afterwards the male fecundates them; with some, however, copulation and an intromission of sperm takes place, the latter being mostly ovoviviparous. The muscles which form so large a portion of the mass of their bodies are white, excessively irritable, and are less perfectly organized than those of the other classes. It is the same with the bones: in some of them (the chondropterygii) the bones remain cartilaginous: the calcarious substance forms no filaments, but remains in isolated grains: in some of them, even the articulations of the spine do not exist, and in the others, the bones, although fibrous and calcarious, differ greatly in solidity, and are remarkably at variance with those of the other classes. The ribs are often soldered to the transverse apophyses. The senses are imperfect; the nostrils are mere rudimental pits at the end of the nose; the cornea of the eye is flat, there is but little aqueous humour, and the crystalline is almost spherical; the ear consists of a vestibulary sac in which are suspended bones of a stony hardness, and in three semi-circular membranous canals, commonly placed in the hollow of the cranium; some genera only have a fenestra ovalis, opening externally; the tongue is most commonly bony and dentated, or horny; the whole skin of the greater portion of them is covered with scales. Some have fleshy cirri or filaments, which may serve for the sense of touch. The prolongation of the spinal marrow into the cranium terminates anteriorly by enlargements, whence originate the olfactory nerves.

The class of fishes in the nature of the skeleton, and in the mode of generation, offers a tolerably well defined division, viz. the cartilaginous, and the bony.

It is in this class of the vertebrata that we find a genus (that of the pleuronectes or flat fishes) where the head is defective in symmetry, such as the two eyes being on the same side.

§ 59. Reptiles offer in their figure, in their structure, and in their functions, much greater varieties, than any of the three other classes of the vertebrata. In fact, some have four feet, others have two before, a third, two behind, and a fourth, none at all. In some, the body is covered with scales, in others,

the skin is naked. Some of them are pisciform in their fœtal state, and as they advance to maturity undergo a true metamorphosis. The organs of digestion greatly vary; the circulation is simple and the respiration partial, that is, the heart, otherwise very variable, transmits the blood into an artery of which one branch only goes to the lungs, the result of which is, that in each circuit of the blood, a part of it only is submitted to respiration. Their lungs are shaped like bags, or at least have large cells. They can suspend the respiratory process, without stopping the circulation: their blood is cold. The quantity of respiration is not the same in this class, the pulmonary artery not being in all, in the same ratio with the aortic trunk from which it arises. They have a trachea and larynx, although voice is not common to all: the alligator is another exception. The females have a double ovary and two oviducts. Some males have a bifurcated penis, others have none. None of them hatch their eggs. The irritability of the muscles is such that it continues long after they are separated from the nervous system, and even from the rest of the body. Their sensations are obtuse. Their nostrils traverse the face, but the ear is incomplete, being confined to a vestibule containing soft bones, the semi-circular canals, and in some a rudiment of a cochlea. We also find under the skin the rudiments of the bone of the tympanum. The crocodiles alone have an external auricular opening. The brain, which is small, may be taken away as well as the head, and motion still continue. Many remain torpid during a part of the year.

From their great variety of organization reptiles have been divided into several families.

The chelonia or tortoises, have a heart with two auricles, each of which receives a different blood, and with one ventricle, having two unequal and communicating cavities, in which the blood from the auricles is mingled. These animals are enveloped by an upper shell formed by the ribs and vertebral laminæ, and by an under one formed by the sternum, both covered by the skin, and by a horny or scaly matter exuded from it. In respiration, the air is drawn in by the nostrils, and forced into the larynx by a sort of deglutition. The male has a simple canalated penis. The female lays very hard eggs.

They live without eating for months and even years, and survive decapitation several weeks.

The sauria or lizards, crocodiles, &c., have hearts resembling that of the tortoise; the ribs are moveable for the purpose of respiration and the lungs greatly extended. The eggs have an envelope more or less hard. They have teeth, nails and scales. The penis is either simple or double.

The ophidia have a heart with two auricles, and no feet. Some of them are venomous. Those which are the most so have insulated fangs and a peculiar disposition of the jaw. Their superior maxillary bones are very small, placed on a long moveable pedicle, analogous to the external pterygoid apophysis; in this is a tooth pierced by a little opening, through which is ejected the poisonous fluid that is secreted by a considerable gland seated under the eye. This tooth, together with several reproductive germs of the same, being placed on the maxilla, is hidden by the moveability of the latter, (when the reptile does not wish to use it) in a fold of the gum.

The batrachians or frogs, toads and salamanders have a heart with but one auricle, and one ventricle. They have lungs, and while young, branchiæ similar to those of fishes. In this first state, the circulation is like that of fishes; the artery is divided and distributed in the branchiæ; the vessels there unite in an aortic trunk which supplies the body and even the lungs. When the branchiæ disappear their arteries are obliterated, with the exception of two branches which unite to form the aorta, and each of which send a small ramification to the lungs. The eggs are membranous, and are fecundated during the time of their being laid or afterwards. At its birth the young one has branchiæ and no feet; the first disappear as it advances in age, and the feet are developed. Some preserve their branchiæ for life.

§ 60. Birds are evidently organized for flight; their figure, the proportion of their parts, their great powers of respiration, whence result their specific lightness and great muscular force, are all combined for this mode of motion. They are biped, their anterior members being solely destined for flight. The chest and abdomen form one single and great cavity, whose

vertebræ have but little motion; the sternum is of great extent, and still further augmented by a projecting blade, resembling a keel. The sternal as well as the vertebral part of the ribs is bony; in this part of the trunk every thing is disposed, so as to give a solid support and muscular attachments to the wings. The shoulders are formed by the merry thought, (the fourchette) the ossa coracoides, which are very strong, and by elongated and feeble scapulæ. The wing is supported by the humerus, the two bones of the fore-arm and the hand, which is lengthened and has a finger, and two others that are rudimental; it has a range of elastic quills. The pelvis, which is very long, furnish insertions for the muscles of the inferior members, and its bones are sufficiently separated, to allow room for the development of the eggs. The lower limbs are formed of the femur, of the tibia, and of the fibula, which are joined to it by an articulation with a spring, which keeps it extended without any muscular effort. There are muscles, also, that go from the pelvis to the toes, passing over the knee and heel, so that the toes are flexed by the weight of the body. The tarsus and metatarsus, are formed by one single bone, terminated below by three pulleys. There is most generally one great, and four other toes, diverging from each other, the number of whose joints increase from the great one, which has but two, to the external one, which has five. The neck is lengthened, is composed of many vertebræ, and is very moveable; the coccygis is extremely short and furnished with quills like the wings. The brain, whose characters are similar to those of the other oviparous vertebrata, is remarkable by its size, as compared to that of the body, which is considerable; but this does not depend upon its hemispheres, which are small. The skin of birds, is, commonly, covered with feathers composed of a hollow stem and barbs; the skin is scaly on the superior surface of the toes, and callous beneath; the sense of touch, must consequently be weak. The eye is furnished with three moveable lids; the cornea is very convex, the crystalline lens is flat, and the vitreous body small. The crystalline has a membrane which appears intended to move it. The anterior part of the eye is encircled with bony pieces. Birds see with great clearness,

both far and near. The ear a little more complete than in the other ovipari, has no stones in the vestibule; the cochlea is somewhat curved; there is a small bone, between the fenestra ovalis and the tympanum, which is deprived of a conch, except in the nocturnal genera. The organ of smell, concealed in the base of the beak, has generally three cartilaginous turbinated bones and no sinus. The tongue is but slightly muscular, and is supported by a bony projection of the hyoides. The rings of the trachea are entire, at its bifurcation there is a glottis or inferior larynx, where voice is produced; the superior larynx is very simple. The lungs, which have no lobes, attached to the ribs, permit air to pass into several cavities of the body, the breast, the axillæ, and even of the bones; this augments their specific lightness and multiplies respiration. The upper maxilla is principally formed by the inter-maxillary bones, and is prolonged backward into two arches, one internal made by the ossa palati, and the other external, by the maxillar and jugal bones, both of which rest on the square or tympanal bone, which is moveable; it is joined to the cranium by elastic laminæ. Both jaws are covered with horn, which supplies the want of teeth, and which sometimes has their form. The stomach is composed of three parts more or less distinct: the crop, which is sometimes wanting, the membranous stomach furnished with numerous secretory follicles, and the gizzard, which has two strong muscles, and is lined by a coriacious membrane. In birds of prey, however, the gizzard is very thin, and not very distinct from the other stomach. The spleen is small, the liver has two ducts, and the pancreas is considerable; there are two appendages to the rectum, sometimes one, and in some genera none, which appear to be the remains of the allantoid.

The rectum, the ureters, and the spermatic vessels or the oviduct, communicate with a cavity called the cloaca, which opens at the anus. The testicles are internal and under the loins; there is but one ovary and one oviduct. Most birds copulate by the simple approximation of the anus; some genera, however, have a small canulated penis. The egg, detached from the ovary, is composed of the germ and yolk only; it becomes enveloped

by the white in the oviduct, and at the bottom of the same canal receives its shell. The heat of the weather, or more commonly, maternal incubation, develops the young.

OF THE VIVIPAROUS VERTEBRATED ANIMALS.

§ 61. Viviparous vertebrata, or mammalia, among which is man, differ from the ovipari, not only in their mode of generation and in their quantum of respiration, but are particularly distinguished by the most perfect animal functions, and a greater intelligence, less under the domination of instinct, and more capable of perfectiveness.

Their general conformation is that of the vertebrata. The splanchnic cavity of the trunk is divided by a complete muscular partition called the diaphragm. With one single exception, they have seven vertebræ in the neck; they have a sternum to which the first ribs are attached. The head is always articulated with the first vertebra by two condyles. The cranium is very similar in its composition. The occipital, sphenoidal, ethmoidal, parietal, frontal and temporal bones, always exist; in the fœtus several of these bones consist of different pieces. The face also has but little variety; it is essentially composed of the superior maxilla, the inter-maxillary bones, the ossa palati, the vomer, the bones of the nose, the inferior ossa turbinata, and of the jugal and lacrymal bones: these united form the upper jaw which is fixed to the cranium: the lower one, formed of two pieces, is articulated by projecting condyles to fixed temporal bones. An os hyoides, suspended to the cranium by ligaments, supports the tongue, which is always fleshy. The anterior or superior members originate from a bony cincture or shoulder, formed by the scapula, not articulated with the spine, supported in many of the mammalia by the sternum, by means of a clavicle. The arm is formed of one single bone, the fore-arm of two, the radius and ulna; the hand which terminates these limbs, is composed of two ranges of small bones called the carpus, of a range of bones called metacarpus, and of fingers, each of which consists of three bones called phalanges. The posterior or lower limbs are similarly formed, and this

similarity is greater or less in proportion as the functions for which the limbs are destined, are more or less alike. Besides this, in all the mammalia, with the exception of the cetaceæ, the lower limb commences by a bony girdle or pelvis, formed by the bones of the hip fastened to the spine: at first these bones are formed of three distinct parts, the illium, the pubis, and the ischium. The thigh is formed of one single bone, the leg of two principal ones, the tibia and fibula; the foot which terminates this member is composed of a tarsus, metatarsus, and toes.

The muscles possess a moderate power of contraction; but their irritability is very dependent on the nervous system. The motion is that of walking. Flight can take place in some, by means of elongated limbs and extended membranes; while others again, having their limbs very much shortened, can only swim. The nervous system of the mammalia is chiefly characterized by the state of the brain and cerebellum. The latter has lateral lobes or voluminous hemispheres, and there is always a pons varolii under the spinal medulla. In like manner the cerebrum always has the corpora striata, and is formed of two voluminous hemispheres, furnished with circumvolutions, forming two lateral ventricles, connected by the corpus callosum.

The eyes, lodged in the orbits, are defended by two lids, and a vestige of a third; the sclerotica is simply fibrous; the crystalline is fixed by the ciliary processes. In all of them, the ear has a perfect labyrinth, with a cochlea, a drum and a membrana tympani and small bones. The nasal fossa traverse the face, have the ossa turbinata, and extend into the sinuses of the bones. The tongue is fleshy and attached to the os hyoides. The skin of the mammalia, generally is covered with hair; the cetaceæ alone are wholly deprived of it.

The intestinal canal is covered with the peritoneum, suspended to the mesentery, a fold of that membrane which encloses the conglobate glands of the chyliferous vessels, and covered with a floating extension of the same membrane, called the epiploon. They have a urinary bladder, that opens, with very few exceptions, into the orifice of the organs

of generation. The cellular lungs and the heart are contained in a cavity formed by the ribs, and separated from the abdomen by the diaphragm, where the surface is free. The circulation is double, and respiration aerial and simple. There is a larynx at the upper extremity of the trachea, which opens into the posterior fauces, this communication depending on a moveable, fleshy veil, called the veil of the palate, or the velum pendulum palati.

What principally distinguishes the organization of the mammalia, is their generation. It is essentially viviparous, i. e. the membranous egg descends and fixes itself in the uterus after conception, which requires a coitus, by which the sperm of the male is thrown into the organs of the female. They have all, like other vertebrate vivipari, at least, in the beginning, an umbilical or intestinal vesicle; they have also, like the lung'd ovipari, an allantoid; but besides this, they have other envelopes, the superior of which, the chorion, fixes itself to the parieties of the uterus by one or more plexuses of vessels, called placentas, that establish a communication between it and the mother, by which it receives nourishment, and probably oxygen. When the fœtus has acquired the necessary developement, it is expelled with the ruptured membranes. The mammæ, secretory glands, produce milk, for the support of the young, as long as they need it.

It is to this kind of organization, presenting, however, certain variations, that man belongs.

§ 62. The mammalia have some organs peculiar to them, such as the hairs of the skin, and the mammæ; otherwise they only differ from the other vertebrata, in the greater developement of certain organs, as the ear for instance, the brain, &c., or by different combinations of the organs of circulation, respiration and motion.

The blood of the mammalia, differs from that of the ovipari in the form of its coloured particles; in the former, they are circular, or rather lenticular; whereas in the latter, they are ovals, or flattened ovoids.

The hairs of the mammalia are not essentially different from the other horny appendages of the skin: like all organs

of this description, they are produced by an excretion on the surface of that membrane.

The mammæ, are also absolutely similar to the other glandular secretory organs.

§ 63. The mammalia, however, still present great varieties in their organization; either in the organs of touch, which are the more perfect, in proportion as the fingers are more numerous and pliable, and less enveloped by the nail; or in the organs of mastication, and consequently in the rest of the digestive organs, or finally, in the organs of generation. The different combinations of these varieties, which occasion many others in all the functions, and even in the intelligence of the animal, have caused this class to be divided into several orders, among which is that of the *bimana*, formed of one single genus, Homo, or man.

§ 64. Man is distinguished from the other mammalia, by some slight differences in the vegetative functions, by some others, more important in the organs of the animal functions, but principally by his *intelligence*.

Intelligence, which distinguishes man, is characterized, above all, by consciousness, reason and free will, by a moral sentiment, and that of a divine *First Cause*.

Besides this, of all the mammalia, man has the hemispheres of his cerebrum and cerebellum, the most greatly developed, and most largely furnished with circumvolutions. This volume of the hemispheres, appears considerable, particularly in comparing it with the medulla, the nerves, the senses and the muscles. His cerebral functions are greatly developed, and very distinct from instinct. He is gifted with speech, and lives in society. He is the only *true*, two handed, and biped animal; his whole body is organized for a vertical position, and his hands are evidently reserved for other uses, than for standing on.

The heart is directed obliquely over the diaphragm, and the aorta somewhat differently arranged from that in the quadrupeds. The organs of digestion are fitted for a varied diet, principally vegetable. The penis is free, and without any in-

ternal bone; the uterus is a simple oval cavity; the mammæ two only in number, are seated in front of the chest.

But as the remainder of this work is devoted to an examination of the human body, it would be superfluous to dwell upon characters, which will be considered in their proper places.*

SECTION II.

OF THE HUMAN BODY.

§ 65. Man, as is evident, partakes of the general characters of bodies, of organized beings, of animals, of the vertebrata, of the mammalia; he has besides this, like all others, those which are peculiar to him: it is the study of all these characters, either of the external and internal conformation, or of their phenomena, that constitutes the object of Anthropology, or the science of man. The immediate end of human anatomy, also called anthropotomy, is a knowledge of the body, that is to say, of all the parts that compose it, and of their mutual arrangement.

§ 66. The anatomist may study the human body in two different states; in the one most common, that proper to the species, and alone compatible with health; or, on the contrary, in its deviations from the natural order. In the first instance, it is the anatomy of the healthy man, hygid anatomy, if we may so express it; in the second, it is morbid anatomy.

In the study of anatomy, we may consider the whole human body, examine the general characters of all its organs, of all its humours, &c.; these are the general views of anatomy. We may, by uniting the multiple organs, in genera, or in systems, according to their analogies of texture, confine ourselves to generic characters, abstracting all the specific differences of the organs; and as for those, which without being mutiple, are extended to all the body, we may only consider the general characters, overlooking the local differences they present in the various

* Vide Blumenbach "de varietate nativà generis humanè—Laurence, "Lectures on Physiology, Zoology and the natural history of man.

regions; such is general anatomy; it imparts a knowledge of the subject, a little more precise, than the more general view above mentioned. But in order to know the human body, in a positive and useful way, we must add to this, an exact knowledge of each organ, in particular, and of each of its regions;—such is the object of special anatomy.

General anatomy, considering together the organs similar as to their texture, and confining itself to what may be generic or common to them all, has for its special, but not its only object, their texture. The special anatomy of the organs, improperly styled descriptive anatomy, treats particularly of their conformation, for it is principally in this, that they differ from each other; their respective situations, is the essential object of topographical anatomy, or the anatomy of the regions.

§ 67. The external form of the human body, is symmetrical;* it is divided into two lateral similar halves, by a median verticle line. This line is even marked, in some places, where it forms what are called raphæ or seams, which, in fact, appears to result from a sort of sewing, or junction of the two lateral portions, originally separated. This symmetry is not equally perfect in all parts of the body; it is more so in the organs of animal functions, and less so in those of the vegetative functions, particularly in those of nutrition. In fact, the bones, the nervous system, the senses, and the muscles, are the most symmetrical parts, while the organs of digestion, of circulation, and of respiration, are less so than the genital organs. It would not be exactly correct, however, to say that symmetry belongs to the former, and is foreign to the latter; it belongs, generally, more to the external parts, and is less perfect in those that are deeply seated; thus the lachrymal and salivary glands, the thyroid gland, the mammæ, the testicles, and all the organs of the functions of nutrition and generation, are symmetrical; while the nerves of the larynx, of the stomach, of the intestines, and the diaphragm, are not. It is also to be observed, that certain parts, which are developed at a later period are less symmetrical than those of the

* See, among others, Bichat, *Rech. Physiol. sur la vie and la mort.* Meckel, *Beitz. zur vergl. anat.* Leipz. 1812.

same kind, which are previously developed: thus, in the nervous system, the medulla, which is first developed, is more symmetrical than the brain; the ribs are less symmetrical than the spinal column, and more so than the sternum. Finally, we may further observe, that the parts are most symmetrical at the period of their formation, and that this kind of regularity, afterwards changes: the stomach, intestines and liver, are less irregular at first, than at a later period; the vertebral column, at first exactly median, gradually inclines to the left, from the predominance of the right arm, and thence results the inclination of the nose, the unequal elevation of the testicles, the frequency of hernia on the right side, &c. Sometimes such a derangement of this symmetry is observed, that the organs of one side, occupy the other, and vice versa; this is called a transposition of the viscera. In this case, which happens in about one, of three or four thousand subjects, and that I have seen four or five times, the trilobated lung, the liver and the cæcum, are on the left, while the bilobated lung, the apex of the heart, the spleen, the sygmoid portion of the colon, &c. are on the right: Individuals thus situated, are not, however, left-handed on this account. The diseases, which affect the symmetrical organs, and those whose seat is in parts that are not so, present a very remarkable difference. It has been even asserted, but upon hypothetical views, that each side of the body, has a greater predisposition to certain maladies, than its fellow.*

Comparisons have also been established, and analogies sought for, between the upper and lower halves of the body. The analogy between the limbs is evident; the shoulders and pelvis, the leg and the arm, the hand and the foot, are constructed on one plan, and differ only so far as their different functions require. As to the analogy, supposed to have been found in man, as in the articulata, between different sections of his trunk, and between the limbs, and the jaws, it rests on a comparison between objects too dissimilar to admit of it.

Carried away by a forced analogy with the radiata, anato-

* See Mehlis, *de morbis hominis dextri et sinistri*. Gotting. 1818.

mists have sought for parts in the anterior portion of the trunk, corresponding to the vertebral column; they think they have found them in the sternum: observation here shows no reasonable approximation, except between the anterior and posterior muscles of the spine. Let us abandon then, comparisons which can tend to no good or useful purpose.

§ 68. The human body is divided like that of the other vertebrata, into trunk and members. The trunk is the central and principal part, that which contains the organs most essential to life, or the viscera. These parts are lodged in three cavities; the inferior is the abdomen, and contains the organs of digestion, of the urinary secretion, and of generation; the middle one, the thorax, contains the organs of respiration and circulation, while the superior, the head, whose cavity is continued into the vertebral column, contains the nervous centre and the senses. It may have been already remarked, (sec. 1,) how much this distribution of the viscera is in relation with their importance in the animal kingdom. We shall see hereafter, that it is equally so with the order of their developement. Considered as a whole, the trunk from before backward, presents a face anterior or external, one posterior or dorsal, and sides; it presents two extremities, the one superior or cephalic, the other inferior or pelvic. The limbs or members, articulated appendages, destined for motion, are divided into superior or thoracic, and inferior or abdominal, both being divided, in several places, by articulations. The different portions of the trunk and members, are again subdivided into a certain number of regions or parts, all distinct and important, on account of the organs placed there. These divisions and subdivisions of the body, are principally determined by the bones. A knowledge of the regions is necessary, in order to determine the exact situation of the organs, and their profound study, the surest or rather the only means of knowing the respective situation of parts: this knowledge constitutes a sort of topographical anatomy, which is of the greatest importance.

§ 69. The human body, like all those that are organized, is composed of solid and fluid parts, which have a similar

composition, and which are continually changed into each other. The fluids are very abundant, and their mass is greatly superior to that of the solids. The exact proportion of the one to the other, however, can not be determined, because on the one hand, certain fluids, as oil, separate from the solids with great difficulty, and on the other, many of the solids can be rendered fluid, and during dessication, disappear among the fluids, and are dissipated with them. To determine this proportion of the liquids to the solids, however, attempts have been made, both by dessicating the parts in stoves or ovens, and by mummifaction; some have considered the proportion as six of the fluids, to one of the solids, while others place it as nine to one. The examination of a mummy, gave a still greater proportion, as this adult mummy weighed only seven and a half pounds. But could the proportion be exactly ascertained in any one case, it would vary according to the individual, the age, sex, constitution &c., inevitably occasioning a marked difference.

Both the solids and fluids are formed of globules, and of an amorphous substance, liquid in the one, and concrete in the other.

§ 70. The chemical composition* of the solids and fluids of the human body, results from a certain number of immediate materials, the chief of which are gelatine, albumen, mucus, fibrine, oil, water, sugar resin, urea, picrocholine, osmazome, zoohematine, phosophate and carbonate of lime, &c. These substances themselves are compound, and the ultimate elements found in the human body, are oxygen, hydrogen, carbon, nitrogen, phosphorus, calcium, sulphur, potassium, sodium, chlorine, iron and manganese—we even find magnesium and silicium.

These elementary substances, in order to form the immediate materials, and these latter, to compose the solid and fluid parts of the human body, are combined in the acts of nutrition and generation in a way that chemistry can not imitate: and it is precisely this act of formation or organization that characterizes life.

* See Orfila. Chimie Medicale.

OF THE FLUIDS.

§ 71. The fluids, or the humours* of the human body, are contained in the solids, and penetrate all their parts. They are composed of molecules, coming from without for the support of the body, and of those which are detached from it to be rejected. Their fluidity is owing, not only to caloric and water, like that of fluids foreign to the organization, but like their composition, it depends upon the vital action. The fluids differ from each other, one being gaseous, another vaporous, and a third a liquid more or less flowing; they also differ in colour; their composition too varies, but it is peculiar to them, and can not be imitated by art.

The fluids may be divided into three kinds, 1st, the blood, a central mass, to which flow, and from which emanate all the others; 2d, the humours which go to the blood from without; 3d, those which emanate from it.

§ 72. The blood is a liquid of a red colour, and of a peculiar odour; it has a nauseous and slightly saline taste; its temperature is that of the body, of which it is even the warmest portion; it is viscid to the touch; its specific gravity is about 105, water weighing 100. It is contained in the heart, and sanguiferous vessels. Its quantity in the adult is considerable, but variable. This quantity has been very differently estimated, varying from eight or ten pounds, to eighty or a hundred.

§ 73. Microscopic observers have made the following observations upon this fluid: the blood is composed of a serous vehicle in which red microscopic globules, are held in suspension; these bodies have been generally considered, either as spheres, marked with a luminous point in the centre, or as being pierced and consequently of an annular form. Hewson, on the contrary, conceived the red particles of the human blood to be lenticular. The important observations of Messrs. Prevost and Dumas and my own, have given the same result. Mr. Home, like Dr. Young, considered the flattening as subsequent

* See Plenck. *Hygrologia corporis humani*—Chaussier. Table synoptique des humeurs.

to the exit of the blood, and that it depended on its separation from the colouring matter. The particles, are, in fact, composed of central globules, transparent, whitish, and with a red envelope, less diaphanous, formed like compressed spheres. The diameter of the particles, in the human species, is about the one hundred fiftieth of a millimetre. As long as the blood is contained in the vessels, and is in motion there, things remain in this state.

§ 74. The blood, out of its vessels, and while it retains its warmth, exhales a vapour formed of water, and of an animal matter susceptible of putrefaction. It soon coagulates, yielding, probably, a little warmth, and gives out a large quantity of carbonic acid gas. This disengagement of the gas, but little sensible while the blood is subjected to atmospheric pressure, manifesting itself only by the formation of canals in the interior of the coagulum, takes place on the outside of the clot, when it is placed under the exhausted receiver of the air pump. We must not confound this extrication of gas and vapour from the blood when taken from its vessels, with a pretended gas that has been supposed to circulate with it.

Shortly after the blood has coagulated into a single mass, it separates into two parts; the coagulum contracting, presses out the fluid part or the serum, it contained. This contraction continues, and consequently, the quantity of this expressed serum augments until putrefaction takes place. Generally the upper surface of the coagulum, contracting more than the rest, becomes concave. If the clot be held for a long time under a small stream of water and gently pressed, the water carries away the colouring matter or cruor, and there remains a white fibrous mass. Thus by coagulation and washing, the blood is divided into serum, cruor, and fibrine.

But let us see what takes place during these operations: as soon as the blood is out of its vessels, the colouring matter of the particles leaves the central white globules, and the latter, deprived of their envelope, unite to each other and form filaments which interweave themselves, forming a net-work, in which are contained both the colouring matter, and many entire particles that have not undergone this decomposition.

During the washing and squeezing of the clot, both the free colouring matter, and particles that remain entire, and that contain white globules in their centres, are carried away by the water at the same time.

The blood, then, contains three principal materials, the serum, the white globules, and the colouring matter that envelops them: the two last united in the fluid blood, and forming the colouring particles, separate, in a great measure, soon after the blood is drawn from the vessels. These materials are in very different proportions, according to the various circumstances of age, sex, constitution, disease, &c. &c.: in the adult and healthy man, the dried, colouring particles constitute a little more than an eighth of the total weight of the blood.

§ 75. The serum has a pale, yellowish green colour; it has the taste, smell, and feel of blood; it is alkaline; it coagulates at about 69°. C. It then resembles the white of a cooked egg, and contains in its vacunæ, a substance that has been taken for gelatine, and which appears to be mucus. The constituent parts of the serum are, water, albumen, soda, and salts of soda. According to M. Brand, we may consider the serum, which is a liquid, and almost pure albumen, as an albuminate of soda with an excess of base. The coagulation appears to depend upon the neutralization of the souda necessary to its fluidity; alcohol and most of the acids, produce this coagulation by removing the soda; and by the action of the galvanic pile as well as by that of heat, the soda transforms a small portion of the albumen into mucus, while the remainder coagulates. The albumen and the serum itself, still present some peculiarities worthy of remark; it is that coagulated albumen, presents globules under the microscope, and that the serum, preserved in a liquid state, in a proof glass for a few days, gradually produces globules, that are deposited at the bottom, and which experience a singular movement of ascent and descent, on heating the glass by holding it in the hand; we must also observe, that coagulated albumen, has the closest analogy with fibrine, from which, perhaps, it does not in any way differ.

§ 76. The cruor of the blood, or the colouring matter obtain-

ed by washing it, is always a mixture of the free red matter of the globules enveloped in the same matter, and of serum. We consequently find, that the most able chemists, have as yet, learned but little respecting the colouring matter of the blood, or the zoohematine. This substance, insoluble in water, but capable of an extraordinary division in it, so as to pass through the filter, is composed of an animal matter in combination with the peroxide of iron. The red colour of the blood has different shades.

§ 77. The fibrine of the blood, or the coagulable lymph of some authors, resembles tenacious elastic downy fibres, presenting under the microscope the aspect of the muscular fibre, being composed of white globules similar to those of the coloured particles of the blood; the fibrine also, like the muscular fibre, being placed in water, resolves itself into globules previous to putrefaction. This coagulable or plastic substance, as well as albumen, appears to be the medium of agglutination which occasions the reunion and adherence of divided parts of the body.

The blood contains also a fatty or oily matter.

§ 78. The blood contained in the arteries, veins, and heart, is constantly in motion; this is called the circulation. During this movement, it undergoes constant and regular changes, which, being exactly balanced, preserve it in a medium state of composition. It receives new liquids, prepared by digestion and intestinal absorption; molecules separated from the organs, are unceasingly added to its mass; it is submitted to the action of the atmosphere in the lungs, where it is revivified; it is then sent to all parts of the body, where it undergoes an inverse alteration, where it furnishes materials that fix themselves in the organs, and where it is deprived of a part of its principles by the secretions. Amid all these changes, none are so striking as those it undergoes in the lungs, where it becomes of a bright red or vermillion, and in the remainder of the body where it assumes a reddish brown colour. These alterations of colour, appear to depend, in the first case, upon an absorption of oxygen, and in the second, of carbone. Besides, the nutritive

principle which the blood distributes to all the organs, it is also the vehicle of the warming principle.

§ 79. The blood varies steadily according to the age, sex, and other circumstances; it also offers accidental changes.

In the fœtus, the blood, which is very dark, has scarcely any coagulable matter. It is the same with the menstrual blood of women. Arterial has a greater proportion of coloured particles than veinous blood. In those individuals that use succulent food, the blood abounds with clot; it is more serous under opposite circumstances. The repeated abstraction of blood, diminishes the proportion of the coloured particles, and even the albumen, but it augments that of the water.

In disease, the blood suffers changes that have not been sufficiently studied. In inflammations, the clot of the extracted blood becomes covered with a white coat, this is the fibrine: and in the clot is also to be seen a large quantity of free colouring matter. In particular cases, such as the scurvy, and in septic disorders, the blood loses its coagulability, it remains fluid. There are many diseases on which an attentive examination of the blood would throw great light.

§ 80. The liquids poured into the blood are the chyle and the lymph. The first comes from the chyme, a grayish, pultaceous substance, into which the aliments are changed in the stomach, and in which little globules begin to appear. Absorbed by the parietes of the intestine, and having arrived in the first chiliferous vessels, it is whitish and hardly coagulable, it becomes more so, and assumes a rosy tint in the glands of the mesentery. Finally, when in the thoracic duct, and ready to pass into the blood, it is distinctly of a rose colour, evidently coagulable, and contains naked globules and particles, which differ from those in the blood, only by an inferior strength of colour. It seems thenceforward to need nothing but the respiratory process to become perfect blood. The lymph, a colourless, viscid, albuminous liquid, but little understood, is the remaining fluid carried to the blood.

§ 81. The humours which emanate from the blood, are separated from it by secretion. We may consider the nutritive matter left by the blood in all the organs, as being of this class;

we may also add to it, those which are produced and deposited, as if in reserve (by a secretion that we may call intrinsic.) in the closed cavities of the body, such as fat, serosity, synovia; but we principally attach to it those which are secreted on the surface of the teguments, external or internal, and of their appendages more or less removed. From their mode of formation, we divide them into three classes or kinds: 1st, in perspiratory humours, which are immediately formed and deposited on the surface by the vessels: such is the matter of cutaneous transpiration, of sweat, of the pulmonary perspiration; 2d, in the follicular humours, which at first are deposited in the follicles of the skin, internal or external: such are the mucus, and the sebaceous matter; and 3d, in glandular humours, formed in the glands, peculiar organs, which have excreting ramifying ducts opening on the skin and mucous membranes, of which they are prolonged ramifications: such are, the saliva, secreted by the salivary glands, the bile secreted by the liver &c. We also divide the secreted humours, from their destination into those which take part in the organism, as the tears, bile, sperm, etc., and into those, which being rejected without answering any purpose whatever, are called, excrementitious. These last are acid, whereas the others are alkaline.

OF THE ORGANS.

§ 82. The organs are the solid* or the containing parts of the body; they it is which above all, determine the form of the body, and which direct its motions.

The figure of the organs is greatly varied: generally speaking, however, their contour is rounded; the surfaces are never perfect planes, the lines very straight, or the angles very entire. In the generality of them, the length is greater than that of the two other dimensions; some are large and flattened: those that have this form and are soft, are called membranes, whatever, in other respects, may be their texture; others again have but little difference in their three dimensions. We determine the external form of the organs by the relation of

* See Chaussier. Table des solides organiques.

their three dimensions; we often also, use comparisons more or less trivial: for most commonly it is rather difficult to determine the form by a comparison with geometrical figures.

In the interior, some organs are hollow, and form reservoirs or canals opening externally; others form cavities closed on all sides; a third, ramified and closed canals, a fourth is full or massive: but they are all areolar, and more or less permeable.

Among the organs, there are some which extend themselves, branching or radiating from the centre to the circumference: such are the vessels, nerves, and the bones themselves. None is insulated, all are interlaced and communicate with each other. Finally, there is a great analogy between the organs, as well as the regions. Some of them being exactly similar, by their union, constitute genera.

§ 83. The colours of the organs are white, red and brown; some of them are transparent, others opaque. Their consistence varies from great softness, to an extreme hardness. They are extensible and retractile, flexible, compressible and elastic, but in very different degrees. The cohesion of some is but slight, while others are endowed with such tenacity as to require very great efforts to break them. These properties of colour and cohesion depend much on the liquids which they in a great measure contain. Thus opaque parts, such as the ligamentous tissue, become transparent by dessication; this same substance, very tenacious and but little elastic when humid, becomes greatly so when dried; elastic parts, such as the tissue of the arteries become brittle by dessication, &c.

§ 84. The organs differ, also, greatly with regard to their texture. At the first glance, we see that several of them are formed by the reunion of bundles of parallel or interwoven threads—we then say their texture is fibrous. Others are formed by the union of layers or laminæ more or less numerous and distinct, and usually, closely united. In others again we find granulations or approximated grains closely united with each other. Some of them have apparently a very compact, uniform or homogeneous texture, but it is in appearance

only; for all are areolar and permeable more or less distinct, all are more or less compound.

§ 85. This first view of the subject is not sufficient to show the exact texture of the solid parts. By a closer examination, we perceive that these apparent fibres, these membranous layers, these granulations, are themselves compound; and as the solids contain the humours, it has been generally believed, that there is nothing but vessels in the solids. This erroneous idea, for the vessels themselves, are compound parts, has been recently revived in a posthumous work of Mascagni. Other authors have admitted that every thing is formed of the cellular tissue, and this by interwoven layers and fibres, or by cells or vesicles adhering to each other. But, the cellular tissue, although it is the principal element of all the parts, is not the only one. As to the idea of a parenchyma, as a base or generating element of all the solids, it is an extremely vague one, and about which we have not been able to agree. Haller,* besides the cellular tissue formed by the reunion of fibres and layers, and which is the most common and extensive, has admitted in the composition of the organs the muscular fibre and medullary substance. This division, with some slight modifications more or less happy, has been since generally adopted. Thus Walther admits a cellular or membranous texture, a fibrous or vascular one, and a nervous one; Pfaff a vascular structure, a fascicular and a cellular one; others a cellular, a vascular and a massive one, or one without cells and vessels. M. Chaussier has added to the three elementary parts of Haller a fourth fibre under the name of albugineous fibre: it is the base of the ligaments; M. Richerand has superadded the epidermoid or horny substance. Among the twenty one tissues admitted by Bichat, there are three which he considers as generators of the others: they are the cellular, the vascular and the nervous. M. Meyer† admits, also three elementary organs: 1st, the cell, the vessel or the gland; 2d, the irritable cellular or muscular fibre; 3d, the sensible fibre or the nerve.

* *De corporis humani fabrica et functionibus.* Tom. 1. Lib. 1. sect. iii.

† *Ueber histologie,* &c. Bonn, 1819.

§ 86. In admitting with Haller the existence of three simple organs, of three elementary tissues, or of three distinct fibres, distinguished from each other by essential characters, viz: the cellular tissue, the muscular fibre, and the medullary or nervous substance, we have not even then arrived at the last point that can be attained by anatomical analysis. By the aid of the microscope, we see that these simple organs, with all their modifications and compounds, can be reduced to two anatomical elements. They are formed, of an areolar permeable animal substance and of microscopic globules, similar to those found in the humours. The first substance alone forms laminæ and most commonly fibres, differing from each other only in the filiform and elongated figure in the first case, widened in the second, and which though sometimes separated, are oftener united: it is from their reunion that result the cells or the areolæ, &c. This first element, which by itself, though variously modified, constitutes the greater part of the organs, united with the other, whose particles it assembles and joins, forms the muscular fibre and the nervous substance.

§ 87. The organs also differ, one from the other, in the phenomena they present during life, and which will soon be considered. It will suffice here, to observe, that the cellular substance is particularly remarkable for its continued contraction, which can be augmented by impressions or irritation; that the ligamentous and elastic tissues, its two principal varieties are noted, the one for its great tenacity, and the other for a great elasticity; that the muscular fibre is, by its contraction, the organ of all the great motions and that the nervous substance is distinguished from all others by the faculty of conducting all impressions to the centre, and the action of the nervous centre to the muscles, &c.

§ 88. The organs differing from each other in their conformation, their texture, their physical properties, their chemical composition, and during life in the action they produce, have been divided into a certain number of classes or genera. These genera should be determined from the whole of the characters taken together, and not from the form only; other-

wise we should approximate things of widely different natures, as all the membranes, and we should separate parts, that with the exception of figure, are precisely alike, as the flat from the long bones, the aponeuroses, from the tendons or ligaments, the nerves from the ganglions, &c.; the fibrous or fasciculated, the lamellated or membranous forms, may belong to parts totally different in all other respects.

§ 89. The ancients divided the solid parts of the body into similar parts, and dissimilar or organic parts. The similar or homogeneous parts are those which divide themselves into particles similar to each other, as the bones, the cartilages, muscle, tendons, &c. The dissimilar parts are those which are formed by the reunion of similar parts, as the hand, the viscera, the organs of sense, and other compound organs. This idea of Aristotle reproduced with some new developments by Coiter, is the origin and foundation of all the divisions of the organs, subsequently established. The division generally admitted in works of anatomy, of bones, muscles, nerves, vessels and viscera, and some others, is well known. But these genera of organs, comprise compound parts, some of them highly so; and on the other hand these genera, and also all that of the viscera, include organs very different from each other—now this deprives us of all the advantages of generalization. M. Pinel, in France, and Carmichael Smith,* in England, having drawn the attention of anatomists to the fact that the simple tissues which enter into the composition of dissimilar or compound parts could be separately diseased, and particularly, inflamed, and that their inflammation was the same, whatever was the compound organ of which they made a part, it soon led to a more complete anatomical analysis, than had hitherto been made, especially as regarded the viscera. Bichat† developing this prolific idea—one worthy of his genius—has arranged all the simple organs under the name of tissues or of systems, in twenty one genera. M. Chaussier

* On inflammation, in Medical Communications, Vol. II.

† Anat. generale, appliquée à la physiologie et à la medecine par Xav. Bichat.

has distinguished the twelve genera of organs, the last comprising the viscera or compound organs. Since then, several authors, adopting their leading principles, have modified the classifications of the two anatomists.*

§ 90. In the midst of this variety, the following is a classification or division of the organs in genera, drawn from the ensemble of their anatomical, chemical, physiological and pathological characters.

The cellular tissue, the principal and general element of organization, should be first; it exists in the whole organic kingdom, enters into all the organs and constitutes the base of all organization.

This tissue, somewhat modified in its consistence, form, and the proportion of earthy matter it contains, forms several other genera of organs.

Arranged in membranes, closed on all sides, in whose thickness it has more firmness and less permeability, it constitutes the serous and synovial systems.

It forms the tegumentary tissue, which embraces the skin and mucous membranes, as well as the follicles of these two kinds of membranes, and the organs producing, hairs, teeth, &c.

It is also the same with the elastic tissue, which is the base of the vascular system, which comprises the arteries, the veins and the lymphatic vessels, and which still belongs to the same order, in approximating to the muscular tissue.

The glandular system, which is formed by the union of the tegumentary and vascular systems, is also of the same order of organs.

The ligamentous system comprising very tenacious and resisting organs, also results from a modification of the cellular tissue.

* See almost all the works on anatomy and physiology since 1801, and particularly J. F. Meckel's *Handbuch der menschlichen anatomie.*—Erster Band. *Allgemeine anatomie.* Halle and Berlin, 1815.—T. Gordon. *A system of human Anatomy*, Vol. I. Edinb. 1815. P. Mascagni. *Prodromo della grande anatomia. Firenze*, 1819.—C. Meyer.—*Opusc. cit.*

Finally, the cartilaginous and bony systems belong to the cellular tissue, and owe their solidity to its condensation and the great quantity of earthy salts that substance contains.

A second order of organs is formed, essentially, by the muscular fibre: this is, the muscles, whether belonging to the bones, to the external and internal teguments, to the senses, or to the heart.

The nerves and the central nervous masses, constitute the third and last order of organs, essentially formed by the nervous substance.

It will be seen that this classification reposes on the basis indicated by Haller, and which truly exist in nature.

§ 91. The order in which the genera of organs should be arranged, may be founded on various bases: if we paid any attention to the universality, more or less great, of the organs in the series of animals, the cellular tissue should be placed first; after it would come, the tegumentary organs; then the muscles and nerves, the vessels, the glands; the cartilaginous and bony, the ligamentous and serous tissues would be placed last as peculiar to the vertebrata. Another order would be followed if we were first to class the kinds of organs that belong to the common or vegetative functions, and next, those which form the apparatus of functions proper to animals. Another order would be established, if, like Bichat we were first to arrange the general systems, as the cellular tissue, the vessels and the nerves, and then the particular systems. It is a matter of but little importance, although it is preferable to arrange the organs from their analogies, as we have done.

§ 92. Several physiologists, still place the épidermic, or horny substance, among the primitive fibres; but this almost inorganic substance, produced by excretion can not be considered as an anatomical element. The characters assigned to it are the following; it contains no distinct cellulosity; maceration reduces it into a sort of mucilage; chemistry proves that it contains albumen, according to some, and mucus according to others, not very different things, since mucus appears to be albumen united to soda. This substance is that which

constitutes the epidermis, the nails, hairs, and all the horny parts of animals. Although a slight difference appears to exist between the horny and epidermic matters, it is not sufficiently great, to prevent us from referring them to the same substance. M. Meyer, who has recently given a new classification of the solids of the human body, looks upon the membrane of the tympanum, the cornea and crystalline, as being formed of this substance, which he calls the scaly, or lamellated tissue; but this approximation has no foundation, particularly the first. The epidermic substances are remarkable for the facility and promptitude of their reproduction.

§ 93. The names of fibre, tissue, organ, &c., generally designate the organic solids. The meaning attached to them should be more particularly specified. We call tissue, every part that is distinct from another by its texture. The tissue differs from the fibre, only inasmuch as the latter is the finer and composing part of it. A tissue may be formed by fibres that are similar or dissimilar. An organ, generally, results from the reunion of several tissues. These distinctions however, are not absolute: thus the cellular tissue represents at the same time, a particular fibre, a tissue formed by that fibre and an important organ of the animal economy. Generally speaking, the fibre is the element, the tissue indicates the arrangement of parts and the organ, a compound part which has a peculiar action. Almost all the solids are formed by the cellular fibre and its two modifications; some tissues have, for a base, the muscular and nervous fibres; one alone, which is the tegumentary tissue, contains the epidermic substance. The organs are, almost always, parts more or less compound; thus in a muscle we find the muscular fibre, the cellular tissue which surrounds it, and, at the extremity, the tendon to which it is attached; in the same way in a nerve, there is a soft and medullary substance in the centre, and externally a particular membrane called the neuralima. Certain parts, such as the stomach, the eye, are still more compound. Generally, every organ or acting part contains cellular tissue, vessels and nerves. The cellular tissue is the most extended: there is no one part where it is not to be found under one form or another. After

the tissue come the vessels—with but very few exceptions, we every where find vessels of different kinds, white or red. The nerves are less abundant than the vessels, and of course, less so than the cellular tissue: the greater number of the organs, however, are provided with them. We may, then, regard the organs, as parts into whose composition the cellular tissue constantly enters, vessels almost always, and nervous tissue generally.

The viscera or splanchnic organs take their name from the importance of their offices. They are the organs, the most essential to life; those by which we live; they are of all the organs the most compound; they are situated in the cavities of the body, called splanchnic. They comprehend the organs of digestion, of generation, and of the urinary secretion, contained in the abdomen; of those of circulation and respiration, which are contained in the thorax, and the sensorial and nervous organs, in the cranium and vertebral canal. It is particularly to the thoracic and abdominal organs, and to the latter especially, that is given the name of viscera.

§ 94. We understand by system or genus, a union of parts of similar texture, such as the bones, the muscles, the ligaments, &c.: this corresponds to the similar parts of the ancients. Parts such as the skin, and the cellular tissue extended over the whole body, and thereby presenting regions, and divisions, but not like the preceeding ones, distinct portions, have also been thus designated. Bichat, particularly used the word, system, in this acceptation. The study of the genera of organs, or of the systems constitute the object of general anatomy, which, in this way, embraces every thing that similar parts have in common, and at the same time whatever the generally extended tissues possess in common in the different regions.

§ 95. The apparatuses are ensembles of organs; sometimes very distinct by their formation, situation, structure and even by their particular action, but which concur in one common end, which is one of the functions of life. It is an error to confound this reunion of parts with that which constitutes a system or a genus of organs. The classification of the appa-

ratuses rests entirely on the consideration of the functions, while that of the systems or the genera depends upon the resemblance of the parts with each other. We have seen as above the enumeration of the genera of the organs; we shall now show how the organs are united in apparatuses of functions.

The bones and their dependencies, viz: the periosteum, the medulla, the greater part of the cartilages, the ligaments, the synovial capsules, constitute a *first apparatus of organs which determine the form of the body*, which serve as supports for all its parts, and particularly as an envelope to the nervous centres, and which, by the mobility of the articulations, receive and communicate the movements determined by the muscles.

The muscles, the tendons, the aponeuroses, bursæ mucosæ, form the *apparatus of motion.*

The cartilages and the muscles of the larynx, and various other parts form that of *phonation*, or of the *voice.*

The skin, the other senses, and the muscles which move them, &c. form the *apparatus of the sensations.*

The nervous centres and the nerves form that of *innervation.*

The alimentary canal, from the mouth to the anus, with all its numerous dependancies, constitute that of *digestion.*

The heart and the vessels, that of circulation.

The lungs, that of *respiration.*

The glands, the follicles and the perspiratory surfaces, form the apparatus of the *secretions;* but the greater part of these organs serving, for other functions, are comprehended in their apparatuses. There remains but the *urinary secretions*, whose organs alone constitute an apparatus.

The *genital organs* constitute a different apparatus in each sex.

Finally, the ovum, and the fœtus it encloses, form a last group or apparatus of organs.

OF THE ORGANISM.

§ 96. The human body, during life, presents many phenomena of different kinds. In it, as in all bodies, mechanical and chemical actions contantly occur; but they are modified by those of life. There is, in fact, in the human body, as in all such as are organized and living, the essential phenomena of life, viz: nutrition and generation, organic actions, whose exercise is subordinate to other actions proper to animals, viz: the muscular movements and the sensations, subordinate themselves to the innervation. These animal actions are directed by the functions of a superior order—those of intelligence.

Besides this remarkable order of subordination in the phenomena of life, there exists between them a connexion, so that the functions of an inferior kind, also hold in dependance, those of a more elevated one, and that all the functions are in such a state of mutual dependance, that the phenomena of life may be compared to a circle, which once traced, has neither beginning nor end. As has been already stated, it is this ensemble of organic actions that is called organism or life.

§ 97. We call function,* the action of an organ or of an apparatus of organs having one common end. These functions have been classed or distributed in several genera; not that these divisions are perfectly exact, or that they are very useful as aids to the memory, since the objects classed are by no means numerous; but because in their study it is necessary to follow some order or other, and it is better to follow a natural, than an arbitrary one. The divisions of the ancients, adopted with some slight modifications by Haller, Blumenbach, Chaussier, and some other moderns, consist in the arrangement of the functions in four classes: the vital, animal, natural or nutritive, and the genital functions. Another division, also taken from the ancients, since the first idea of it, is to be found in Aristotle, which has been pointed out by Buffon, Grimaud, &c., and which has been adopted and developed by

* See Chaussier, *Table synoptique des fonctions.*

Bichat and Richerand, consists in classing the functions in those of the species and in those of the individual, and these latter, in functions of relations or animal functions, and in those of nutrition or organic functions.

§ 98. The following is a very natural order, in which the functions may be classed. Some are common to all organized bodies, vegetable as well as animal; if not by all their actions, and all their organs, at least by the result. These are the common, organic, or vegetative functions. 1st, nutrition, which comprehends, digestion, absorption, circulation, respiration, and the secretions, and whose definite result is the perpetuating the individual in its form, composition, and temperature; 2d, generation, which comprehends the formation of germs, that of the sperm, fecundation, and the development of the fecundated germ, and whose result is the perpetuity of the species, or of a succession of similar individuals. The other functions are proper to animals; they are: 3d, the muscular action whose results are locomotion, gesture, and voice, and moreover, the muscular movements necessary to the execution of the two preceding functions; 4th, the sensations, and 5th, the nervous action or innervation. There is yet another order of functions, belonging exclusively to man, viz. the intellectual, which, in other animals, that most resemble him, exists only in appearance. Finally, man not only exercises his individual functions, and those of generation, but, living in society, he exercises collective actions, whose observation and bearing are foreign to physiology and medicine.

§ 99. While bodies are at rest, we perceive nothing but the qualities by which they strike our senses. While in action or motion, we can still only perceive phenomena, or changes perceptible to our senses. Among these qualities and phenomena, some are common to all bodies, others are peculiar to organized and living ones; these last have their peculiar qualities and phenomena, in a word, their properties. Properties, are in fact, nothing else than sensible qualities and phenomena. When the latter reproduce themselves in an order, all of whose conditions we can determine, we know the law of such phenomena, that is to say, the rule they follow, and to which, it ap-

pears to us they are subject: this law when it is general is called theory. Beyond this, we know nothing. But we admit in general, that matter is inert, and every time we see it in motion, we suppose a cause of motion that makes it act, and which we call force. Thus, organic matter being in action during the entire life of organic bodies, we say that life is caused by a vital force.*

This force has been considered as a different substance from that of the organs, and of which these latter were the instruments, at one time it has been considered rational, at another the reverse. It has also been regarded as a faculty proper to matter; either to organic solid matter, or to that which is fluid. It has also been thought to be the result of organization, i. e. of the assemblage of all the solid and liquid parts of an organized body, etc.

It would, doubtless, have been better in a physical science, like that of the organization of life, had we confined ourselves to the observation of bodies and facts.

§ 100. The organic or vital phenomena, differing from each other, the vital or organic forces that have been admitted, must consequently be of several kinds.

There are phenomena of organic formation, such as those of nutrition, generation, the reparation of lesions, reproduction, etc. A force or power of formation, has consequently been admitted under the name of plastic force, formative force,† vital affinity; it is common to all organic bodies, and to all their parts.

§ 101. The solids of organized bodies, and particularly of animals, receive impressions from various agents, that are immediately followed by movements more or less appreciable: these are called movements of irritation, and the force or the cause to which they are attributed, irritability.‡ All animal parts are more or less susceptible of it. We notice three principal varieties of it. In the cellular tissue where it is weak, it

* *See* Reil. *Von der lebenskraft, in archiv. furv die physiologie.* B. I. Halle, 1795.—Chaussier. *Table synoptique de la force vitale, etc.*

† *See* Blumenbach. *Uber den Bildungstrieb.* Gotting.

‡ *See* Gautier. *de irritabilitatis notione, natura et morbis.* Halæ, 1793.

is called tonicity; in the vessels where it is more marked, it is called vascular contractility, and in the muscles where it is greatest, muscular irritability or myotility.

It is remarkable that all these movements consist in contractions. It has been thought, however, that certain movements depended upon an expansion, an elongation, or a turgescence,* this appears to have been caused by a want of close observation.

§ 102. In man, and in those animals that have distinct nerves and a nervous centre, the impressions received are transmitted by the nerves, and felt at the centre, and the centres transmit their action to the muscles by the nerves. The cause to which these phenomena are attributed, is called the nervous force, in one word, sensibility. Among the sensations, some are extremely obscure, and but vaguely perceived.† They are pretty nearly every where extended, particularly in the mucous membranes. In a state of health, they constitute a general sentiment of well being; when they are increased by certain causes, they give rise to a morbid sensation called pain. There is no part which may not become the seat of this morbid sensibility. The other sensations are distinct, and some of them altogether special.

As to the nervous action on the muscles, it directs their irritability; its power is also extended to the vessels, particularly to the smallest.

Moral and intellectual acts, differ so widely from organic phenomena, that it is impossible they can depend on the same cause; they would in this case be necessary and blind, instead of being enlightened and free. Physiology, which on the one side is met by natural philosophy, here encounters moral philosophy or metaphysics.

§ 103. The functions are not exercised, or if you will, the vital forces do not enter into action *spontaneously*, but by means of stimulants or exciting causes; whether they be the bodies which act on the external and internal surfaces of the body, or the blood which penetrates all its parts. In relation

* *See* Hebenstreit, *de Turgore vitali.* Lipsiæ, 1795.

† *See* Hubner, *de Coenæsthesi;* Halæ. 1794.

to their effects, stimuli differ materially from each other. As to the subjects on which they act, their difference is not less, and depends on age, sex, and above all, on the diversity of the organs, which feel more or less the action of the same agent.

Every thing being united in the organization, the action of an organ is not isolated: those which have centres, influence all that are subordinate to them. Others perform their functions by association. Some of them to supply the want of it, execute the action which is interrupted in another. There is not a single one of them, which, being extraordinarily excited, by an appropriate stimulus, does not influence more or less the whole organism.

OF THE DEVELOPMENT AND DIFFERENCES OF THE ORGANIZATION.

§ 104. Each organ, each action, and consequently, the entire organism, presents stadia or degrees of development and perfection. A first period is that of youth, of a successive growth and perfection, or a second, very short one, is that wherein the organization remains in a state of maturity; a third is that in which the organization is progressively altered, and naturally arrives at death and destruction.

§ 105. It is in the beginning of life, that the similitude between the lateral parts is the greatest. The heart is then vertical and median, the lobes of the liver nearly equal, the stomach vertical, etc. The upper and lower members are exactly alike, at the moment they make their appearance, and for a short time after. The genital organs of both sexes are at first similar. It is also in the commencement of life that animals bear the strongest resemblance to each other. The relative size of the parts changes with age: thus the nervous system, the senses, the heart, the liver the kidneys etc, are at first large, in comparison with the rest of the body, while on the contrary, the intestine, the spleen, genital organs, lungs, members, etc, are very small as regards the rest of the body, and the other organs. This added to the fact, that certain parts disappear, or greatly diminish with age, constitutes a species

of metamorphosis; thus the membranes of the ovum and the placenta, the pupillary membrane, the milk teeth cease to exist, and the surrenal capsules and the thymus gland, greatly diminish, and finally, almost totally disappear.

§ 106. The organs and humours are not always in the same proportion. In the beginning the embryo is nothing but a nearly liquid molecule; in time the proportion of solids increases and continues to augment till the end. The colour is also gradually developed; at first all the parts are white, the colouring of the blood and other parts takes place, by degrees. There is at first no determined texture in the organs: there is even no globules in the beginning, while at a later period, the whole mass of the body appears, globular, or granulated, after which fibres, lamina and vessels become distinct. All the organs are not developed at one time. Even those of the same genus or system are not all formed together. The external form or configuration is drawn before the consistence, texture and composition are fixed; for, as we see in the fruit of the almond which has already its form, and is as yet a mere glairy liquid which will successively acquire the consistence, texure and composition proper to it, so the nervous and bony systems already have partly their form while yet liquid. The cellular tissue; and the vessels permeable by liquids, diminish from the beginning to the end of life; it is, above all, this change which continues after the end of the growth, that essentially appears to constitute the period of the deterioration of the organism and of old age.

§ 107. The organs are formed by separate parts that afterwards unite; thus the nervous medulla is at first a double cord; the intestine and the cavity of the trunk, at first open in front, afterwards close—it is also the same with the spinal canal. The vessels, at first, are isolated vesicles which stretch and communicate in the mass of the body: the kidneys, at first multiple, coalesce and adhere; the bones which in the cartilagenious state, lengthen themselves by a species of vegetation, afterwards become ossified in separate parts which then unite, &c. Traces of this formation, remain in certain places, stronger in some, weaker in others; thus the raphe of the skin,

the middle suture of the os frontis, the median line of the uterus, &c. are sufficiently apparent marks of a reunion of the two halves; on the contrary, in the superior portion of the sternum, in the body of the vertebra, these traces, are, generally, completely effaced.

§ 108. All the phases through which the human organism passes, correspond with permanent states or conditions in the animal kingdom. We could here accumulate the proofs of this important proposition by drawing a parallel between the human fœtus in its various stages of development and the degrees of organization of the animal scale. Some few examples, however, will suffice. The embryo is at first a mere bud or germ, placed on a vesicle, such, are some of the most simple worms. At a more advanced epoch, it is a little vermiform body without distinct members or head; this is the case with the annelides; still later, the members are equal and the tail protrudes: such is the fact with respect to the greater portion of quadrupeds. In the nervous system, we first see the nerves with their ganglions: such is the case with all the invertebrata provided with nerves; at a later period we can distinguish the vertebral and cranial medulla, the tubercles of the latter, and as yet only the rudiments of a cerebrum and cerebellum: this is the case with fishes and reptiles; still later these last parts increase much more than the tubercles and the encephalon is successively that of birds and the mammalia, until, finally, by the predominance of the cerebral and cerebellous lobes, it becomes that of man himself. We should see in following the development of the bones, that they are at first mucilaginous, then cartilaginous, afterwards bony and in this state, separated in pieces, which are afterwards welded together; in comparing this development with the state of the bony system in the lamprey, in the cartilaginous fishes and in the oviparous vertebrata in general, we should have another proof of the proposition advanced. It would be the same if we were to pass in review all the genera and all the apparatuses of organs.

§ 109. Man is distinguished from all other animals by the great rapidity with which he passes through the first epochs

of his formation or of his development; consequently, it is also difficult to perceive in him these first changes. The comparison of man with animals, and of man with himself at different ages, is a point of comparative anatomy, which already rich in a great number of facts, recommends itself by its importance to the observation of the accoucheur.

§ 110. As may easily be imagined, the organic phenomena follow the successive development of the organs. In the embryo, there is only an almost direct absorption and assimulation of the nutritive matter; afterwards the vessels become apparent, and it is the circulation which then, every where distributes the materials of nutrition; the secretions then begin to form, and the blood of the fœtus, brought into contact with that of the mother through the medium of the placenta, derives from it a kind of *branchial respiration.* At birth, atmospheric respiration and digestion are added to the other nutritive functions, and the animal functions enter into exercise; and here, as in the whole animal kingdom, we see the organs and their functions the last developed, hold all the rest in a state of dependence, and life to result from the connexion of organic actions with each other.

§ 111. The organization of man presents differences in the sexes:* besides those that exist in the organs of generation, there are others in the general form of the body and in the proportion of its parts. Man is generally larger than woman; the total weight of his body is about one third greater. The contour is more rounded in woman, bolder and more salient in man; the trunk of woman is shorter, and the inferior extremities longer, so that the middle of her body is lower in her, than in man—the abdomen, and the pelvis particularly, are larger in proportion than the shoulders and chest, which is short, and tapering. The organs contained in the abdomen, are larger, and those of the breast and neck smaller, in proportion to the rest of the body, in woman than in man; the bones and the muscles are less developed, the adipose tissue

* See J. F. Ackerman, *de discrimine sexuum præter genetalia. Mogunt,* 1787.—*Ejusd. historia et ichnogr. infantis androgyni—Jenæ,* 1805.

more so; the general texture of the parts is softer and more lax; the hairs weaker and less numerous. As to the genital organs, the very great differences they present, do not destroy their essential analogy. The external characters of the sexes we have just indicated, appear to depend upon the existence and action of the ovary in woman and of the testicle in man. In the embryo, where the sex is doubtful, there are no external appreciable differences; in the fœtus and infant they begin to show themselves in proportion as the genital organs are developed: in puberty the sexual characters are most perfect, in old age they become less so. The want of a complete development of the ovaries or testicles, their changes by disease, and their ablation, likewise prevent the general differences of the sexes from establishing themselves, or efface them more or less completely. The causes of the difference between the sexes has been sought for in a supposed predominance of the coagulating principal, or of oxygen in the male and of the nutritive matter in the female.

§ 112. The human species presents differences of organization, hereditary in the races or varieties,* scattered over the globe, and that may be considered five in number, and of which there are three principal ones, viz: the Caucasian, the Mongol and the Ethiopian, and the Malay and American races.

§ 113. The Caucasian, to which we belong, is remarkable for the beauty of the form and the proportions of the head, in which the cranium is much larger than the face; a fact of which any one will be convinced by simple inspection, as well as by the application of cephalometers. The cranium is high and rounded, the face is oval and its parts but slightly salient. The colour of the skin is generally white and rosy; that of the eyes blue or brown, that of the hair, which is generally abundant, fine and long, varies from white to black.

The caucasian is peculiarly remarkable for the development of his intelligence, for civilization and the culture of philoso-

* See Blumenbach, *op. cit.*—Lawrence, *op. cit.*

phy, the sciences and the arts. The coloured races on the contrary have the senses in greater perfection.

§ 114. The mongol is recognised by the strength of the trunk, the smallness of the members, the almost square form of the head, and the obliquity of the forehead, by the breadth and flattening of the face, the projection of the cheek bones, and by the separation, narrowness, and obliquity of the eyes; the skin is olive; the hair is straight, black and short; the beard scanty, and sometimes totally wanting.

§ 115. The negro has the trunk slender, particularly at the loins and pelvis; the superior members are long, particularly the fore-arm; the hands are small, the feet large and flattened; the knee and foot are turned outwards; the head is narrow and elongated; the inferior part of the face projects; the nose is flattened; the anterior teeth are oblique, and the lips salient; the skin, the iris and the hair, are black; the latter is crisped, and the beard thin.

§ 116. The anatomical characters of the American race are less defined, and seem intermediate between the caucasian and the negro. The skin is of a copperish red; the hair is black, straight and fine, and the beard scanty or wanting.

§ 117. The malay is like the American, but little distinguished by characters drawn from anatomy, he appears to be between the two first. In this race, the skin is brown or tanned, and the hair thick and curly.

§ 118. Fabulous varieties have also been admitted:—this is no place to speak of them. Albinos originate from a morbid change. In each race we also find sub-varieties more or less marked. In different countries, often nearly approximated, we generally observe a national character, at least, as regards the physiognomy; but in each race also, in each nation, and even in much more limited divisions, we sometimes find individuals very different from others; thus it is by no means very rare, that we find in the negro, all the anatomical and physiological characters of the caucasian race, colour excepted, and *vice versa*. The varieties, otherwise, are confounded by insensible gradations. We must then consider these varieties in the species, as accidental differences only, the causes of

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which, it is true, are not easy to determine, but how confined also, are the observations made on such a subject, and consequently how unequal to the determining of the conditions of a phenomenon for the production of which nature has spared no time.

OF THE ALTERATIONS OF THE ORGANIZATION.

§ 119. The human body does not always arrive at the term of its existence by a progressive alteration of the organization. Most generally the development stops, deviates from the usual course, or the organization regularly developed, becomes altered by the action of external agents. The body thus altered in its conformation, in its texture, in its composition, is the subject of morbid anatomy. To the physician, this kind of anatomy is the necessary compliment of the anatomy of the healthy body; it is to pathology, what ordinary anatomy is to physiology; pathology can no more exist without morbid anatomy, than physiology without anatomy; there can no more be morbid phenomena or symptoms without altered organs, than functions without regular organs, than phenomena without bodies, motion without matter. Morbid anatomy is the foundation of pathology.

§ 120. The derangements of the organization, may affect the conformation of the body, in general, or of some organs: this constitutes a first class, that of vices of conformation. Some are original or primitive, others are secondary or acquired. These latter are numerous and very different from each other. As to the first, attentive observation has caused the discovery of one of the most important laws of the development of the organization. These vices, are in fact, and essentially, only a permanent state, in one or several organs, stadia or degrees, through which they pass in the progressive development. Thus, for instance, the numerous vices which consist in a fissure or separation, more or less great, on the median line, as the hair-lip, that of the roof of the mouth, or of the velum palati, the opening of the sternum, of the diaphragm, of the wall of the abdomen, of the anterior parietes of the bladder, of the

pubis, of the urethra, of the perineum, spina bifida, cranium bifidum, etc. are merely the permanent state of a fissure, which should only be temporary.

The junction of the fingers, the prolongation of the coccyx, the persistence of the pupillary membrane, the bifid uterus, the testicle in the abdomen, etc, are merely, situations, divisions, reunions, states of continuance of organs, which ought only to be temporary, and which have remained permanent. It is the same with the anormal communications of the cavities of the heart, of the opening of the bladder at the umbilicus, of the existence of a cloaca and congenital umbilical hernia.

Sometimes, it happens, that when one of these vices exists, the rest of the organization is developed, nearly, as usual; but in certain cases, one imperfection is the unavoidable cause of others, and here is one of the most striking examples; if the olfactory nerve and ethmoidal bone which contain it, are arrested in their development, the orbits and the eyes will become more or less intimately confounded, and will constitute what is called a cyclops.* It is the same with respect to several others.

This part of pathological antomy, which has been regarded as a mere matter of curiosity, is on the contrary, of great interest to the physiologist, and the pathologist.

§ 121. The derangements of the organization, may also consist in an alteration of the texture, and composition of the organs.

The following are the effects and productions of irritation, of inflammation, and of other less known derangements of the secretions, and of nutrition: adhesion, generally, and the differences it presents in the various divided organs; pus and other liquid products of inflammation; transformations of one tissue into another resembling healthy tissues; the degeneration or the changing of an organ into a substance that has no analogy with anything in the regular organization; the hard or soft concretions which are formed in the ducts and reservoirs of follicles and glands, and which are owing to an alteration in the liquid secreted, and in the secretory organ, are so

* *See* Béclard. *Mémoires sur les fœtus acéphales.*

many highly important genera of this class, the study of which, is of no doubtful use, as may appear that of the vices of conformation.

We must add to these two classes, that of intestinal worms sufficiently numerous, and that of the parasitic animals which may exist in man.

OF DEATH AND THE CADAVER.*

§ 122. Death† is the final and total cessation of the functions of life, soon followed by the dissolution of the body. It is the necessary and inevitable result of the successive changes of the organism. It is seldom, however, the last term of life arrived to extreme old age; most generally it is occasioned by accidental causes.

Life consists, essentially, in the reciprocal action of the circulation of the blood, and of *innervation*, death always results from the cessation of this action. Senile death, appears to result from the simultaneous weakening of these two functions, and the simultaneous alteration of their organs, and morbid or accidental death from the primitive alteration of one of the two organs, and of its function. It is always, in fact, by the interruption of the nervous action upon the organs of the circulation, or by the cessation of the action of the blood on the nervous centre, that death is determined by accident or disease. But the blood may cease to act upon the nervous system, so as to continue life; either because the heart no longer sends it there, and that the vessels cease to conduct it effectually; or because the blood is no longer submitted to respiration; or because it is not purified by the secretions from noxious principles, by the urinary depuration in particular; or because the intestinal digestion and absorption do not furnish it with nutritious materials; or, finally, because deleterious substances are carried into the mass of this fluid from without.

§ 123. The cadaver† is a dead, organized body; but this

* We prefer this word, although not English, to any paraphrase. The *cadaver*, is the *body* after the extinction of life. TRANS.

† See Chaussier. *Table des phenoménes cadaveriques.*

term is particularly applied to an animal, and chiefly to man, who has ceased to live. The body, in which the vital action is insensible, soon looses its heat and mobility. For a few moments after, we may observe in it some particular phenomena the last vestiges of that life which has just ended, and which are called primitive cadaveric symptoms. But the cadaver has an ephemeral duration only. Putrefaction always commences after a certain and generally, very short time, unless under peculiar circumstances; its elements separate, and the bones alone remain for a while, to be destroyed in their turn. Although all dead bodies are disposed to the changes of which we are speaking, all do not alter in the same space of time, or in the same manner. The age and constitution of the individual, the proportion of his humours, the nature of his death, the circumstances which have preceeded it, the season, climate, state of the atmosphere, the bodies which surround the corpse, &c., are all so many circumstances, each of which has an influence, *sui generis*, upon the development of cadaverous phenomena; besides this, each organ undergoes peculiar changes. The following are the most general alterations that ensue:

§ 124. The warmth, as well as the other phenomena of nutrition, sometimes diminishes immediately previous to death, and ceases altogether shortly after. The cooling takes place gradually and commences at the surfaces and extremities. It proceeds so much the faster, as the subject is the more exhausted by old age or disease, deprived of blood, lean, and the atmosphere more cold; under these circumstances it may be effected in two or three hours, whereas it generally requires fifteen or twenty hours; it may even require several days. The blood is blackish, and generally preserves its fluidity and motion while the body is warm; the aorta and principal arteries are emptied; it accumulates most commonly in the vena cava, in the auricles of the heart, the vessels of the lungs and even in the veins generally, a circumstance resulting from the elasticity of the arteries and bronchiæ and from the mechanism of the chest. The accumulation of blood in the veins varies according to the causes of death; where there has been

dyspnea or suffocation, it is very considerable, and in this case, there are sometimes congestions, turgenscenscies, erections, and even sanguineous transudations. The blood, obeying its gravity and the action of the arteries, accumulates and forms livid spots in those parts that are dependent at the moment of death, and while the body is yet warm, the rest of it remaining pale and yellowish. During all this period of cooling, the body is in general soft and flexible, the eyes half open, the lower lip and jaw pendent, the pupil dilated: congestions that have existed during life, sometimes disappear; the sphincters are relaxed, and sometimes, through a remaining vestige of contractibility, an expulsion of the fæces takes place, and even parturition. The muscles may yet be irritated by various stimuli, by galvanism particularly.

§ 125. The soft parts remain flexible and the blood fluid, as long as the body preserves its warmth; no sooner has that abandoned it, than the blood coagulates, and the soft parts become stiffened in a greater or less degree. The coagulation of the blood varies greatly; generally it is either white or lemon coloured concretions, which are moulded in the vessels; sometimes the blood assumes the consistence of jelly, or even remains completely fluid. The cadaverous stiffness is a constant phenomenon, and is characterized by the firmness of the soft parts and the resistence and immobility of the articulations. It begins in the trunk and extends first to the superior, and then to the inferior extremities. This phenomenon which appears to depend, essentially, on the last contraction of the muscles, and also on the general cooling and coagulation of the fluids, presents a great difference as regards the moment of its manifestation, its intensity and its duration. Thus in death from old age, in that induced by a slow exhaustion or by excessive fatigue, from gangrenous, putrid, or scorbutic diseases, &c., the stiffness ensues very promptly, is not very intense, and scarcely lasts for one or two hours. On the contrary in strong, muscular subjects, who expire suddenly by violence; after most asphyxies and acute diseases, the stiffness does not come on for twenty or thirty hours, becomes very considerable and remains for three or four days. The rigidity

of the soft parts, afterward spontaneously ceases, and in the same order of its manifestation; it is replaced by a softness that gradually augments; the parts are abandoned to their gravity, take a consequent direction and sink. The coagulated fluids become again liquified, and their fluidity even seems to increase. Such are the first phenomena of putrid decomposition.

§ 126. In some cases and most commonly after a sudden and violent death, there is a considerable and rapid disengagement of gas, either in the intestinal canal, the serous cavities, the cellular tissue or even in the vessels themselves: from this result other various remarkable phenomena. The tympanites of the abdomen pushing up the diaphram, freqently occasions a discharge of mucus from the mouth or nares, and sends the blood to the neck and head: whence, the swelling of the face, the lustre of the eye, the contraction of the pupil; it also causes a reflux of the matter in the stomach to the pharynx, larynx, the nasal fossa or the mouth; it also occasions a determination of blood to the genitals, the excretion of gas, of fæces, and sometimes, even a rupture of the abdominal parietes. The development of gas in the cellular tissue constitutes the cadaverous emphysema; its disengagement in the heart and vessels occasions a motion in the blood and even its flow from wounds, phenomena styled, cadaverous cruentation.

§ 127. Putrefaction is an intestinal movement, the inverse of the organic action, which establishes itself in the body, destroys all the combinations, which were formed by the vital action, separates their molecules, reduces them to a simpler state of composition, reduces them to gas, vapours, putrescence and earth, and thus restoring them to the general mass of inert bodies. Besides the cessation of life, putrefaction requires as other requisites, the contact of air, and a certain degree of heat and humidity. The extent and combination of these requisites, occasion much variety in the phenomena of decomposition.

§ 128. It commences commonly, the instant the coagulation and rigidity cease: from that moment the liquids begin

to be resolved, and the soft parts, gradually, to soften and relax. The body, which exhales from the beginning a vapour, whose loss diminishes its weight, then gives out a stale and musty odour. The blood and other humours transude from their reservoirs, and impregnate the surrounding parietes and parts with their colour and odour: thence the colouring of the veins and surrounding cellular tissue which is red, the spots printed on the stomach and the intestines, by the liver, the spleen and gall-bladder, the sero-sanguineous infiltrations in the cellular tissue and serous membranes, their rose, red and brown colours, and the tinging of the abdomenal parietes with a bluish or greenish tint. The humours of the eyes transude, whence the destruction of the cornea and by mingling with the corpuscules that flit about in the eye, they form a slimy coat or covering.

In this first period, the muscles redden litmus paper.

§ 129. Putrefaction, which, as respects the regions, generally commences in the abdomen, on account of the excrementitial matter there accumulated; which, as respects the organs, begins in the softest and such as are the most impregnated with fluids, as the encephalic mass, and which also first attacks engorged parts, or such as have been altered by disease or the kind of death, soon becomes general. The epidermis is detached, and raised by masses of a brownish sanies; the muscles by the imbibition of the fluids become glutinous, greenish, pulpy and ammoniacal; a putrid and nauseating odour is disengaged.

§ 130. Finally the texture disappears in toto; the soft parts, confounded with the fluids are reduced into a half fluid putrescence, mixed with bubbles of gas, exhaling the most infectious odour, and the most pernicious vapour. Soon, nought remains but the bones, which in their turn become friable and pulverulent, leaving nothing but a small earthy residuum.

§ 131. When the conditions of putrefaction are favourable, as after certain diseases and in hot and humid times and places, it commences at the moment of death, and runs through its stages with the greatest rapidity. Under contrary circumstances it is slow, and may be completed only after the lapse

of years. It may be even indefinitely suspended, or its phenomena much modified. Thus a body enclosed by ice, may be preserved without undergoing any sensible change, as long as the congelation lasts: thus also, a body dessicated by a dry, and hot atmosphere, like that of the deserts of Africa, or by an absorbent earth, as in certain caves, or by the heat of the oven or stove, or by various chemical operations, may become nearly imputrescent. In like manner, a body plunged into the water and kept there, in humid earth, or in one saturated with cadaverous products, may be transformed into adipocire, become saponified by the reciprocal action of its fat, and the ammonia, which results from the decomposition of the flesh.

§ 132. The body, for some time after death, still preserving nearly the same organization and composition as when alive, is the subject on which anatomy is studied. As numerous changes, however, which continue to augment, commence from the moment of death, we must, by the examination of living animals, rectify the ideas we have acquired by that of bodies deprived of life.

Every subject is not equally fit and proper for the study of anatomy. For long and consecutive dissections, we should not select those which have yielded to putrid diseases, or fatigue, those that are still warm, or those in which putrefaction has been rapid or is much advanced: extreme cleanliness is absolutely necessary in all anatomical researches. If a wound is received while dissecting, particularly if the subject be not a proper one, it should be washed and cauterized on the spot.

§ 133. The anatomist, considers in each solid part of the body, 1st, its configuration or its form, external as well as internal, if it is hollow, and its position, whether symmetrical or irregular; 2d, its situation in the whole body, and relative to other parts, as well as its relations of contact or connexion, more or less intimate with them; 3d, the direction of its great diameter which may be parallel, oblique, or perpendicular to the axis of the body; its metrical extent either as relates to the body or some of its parts; 5th, its physical proportions, either as relative to the attraction of its molecules, as its density, its cohesion, elasticity, &c. or as relates to the manner in which it

is affected by light, as its colour and transparency; 6th, its anatomical composition and its texture, or the arrangement of its integral parts; 7th, its properties and chemical composition; 8th, the liquids or humours it contains; 9th, the properties it enjoyed during life; 10th, its vital actions, and the connexion of this action with the others; 11th, the varieties it presents in the ages, sexes, races, and individuals; 12th, its morbid states, and 13th, its cadaverous phenomena and changes. Although several of these considerations seem to belong to the study of natural philosophy, chemistry, physiology, and pathology, rather than anatomy, there is none of them that will not enlighten the anatomist, not one of them that he should neglect.

GENERAL ANATOMY.

CHAPTER I.

OF THE CELLULAR AND ADIPOSE TISSUES.

§ 134. These two tissues have been generally confounded under the name of cellular tissue; they are, however, very different, and should be separately described.

SECTION I.

OF THE CELLULAR TISSUE.

§ 135. The cellular tissue, has been so called, on account of the areolæ it forms, improperly, perhaps, styled cells. It is a soft spongy tissue, extending through the whole body, surrounding all the organs, uniting them, and at the same time separating them from each other; it penetrates into their substance, and has the same mode of existence with all their parts; entering into the composition of all organized bodies, and of all organs, it is the principal element of organization.

According to the light in which it has been viewed, the different names of substance, body, system, organ, membrane, cribrous, mucous, glutinous, intermediate, areolar, reticulated, laminous, filamentous tissue, &c. have been given to it. The name of cellular tissue is perhaps no better than the others; it is, however, more generally adopted.

§ 136. Notwithstanding the very great extent and importance of this tissue, which must have arrested the attention of anatomists, at an early period, no description of it is to be found in ancient authors. Hippocrates, speaks of the general permeability of the tissues, when he says, that the whole

body perspires without, as well as within: the first ideas of the existence of the cellular tissue, have been sought for in this passage. What Erasistratus called *parenchyma*, corresponds, perhaps, with this tissue. But we find no exact ideas, as to its disposition, until the time of Charles Etienne, Vesalius, and Adrian Spigel: even these anatomists, and a great many of those who succeeded them, have only indicated the cellular tissue, in the different places where it is met with, as around the vessels, muscles, fat, &c. Kaaw Boerhaave, Bergen and Winslow, were the first who published some general ideas, on the continuity of this tissue, in the different regions; but it is since the time of Haller, only, that it has been presented to us in a correct point of view. The cellular tissue has occasioned many treatises. Schobinger, Thierry, W. Hunter, Bordeu, Fouquet, Wolff, Detten, Lucæ, de Felici, paid particular attention to it. Their works have added but little to the description given by Haller; but several of them are remarkable* for ideas, more or less correct, of the nature and functions of this tissue. All anatomists, and those in particular, who occupied themselves with general anatomy, have spoken of it in their books: Mascagni, alone, scarcely names it. There are no good plates of the cellular tissue, in fact, having no determined form or colour, it is impossible to represent it; Wolff has made the experiment, but has failed.

§ 137. In order to facilitate the study of the cellular tissue, we examine it successively, in two portions, of which one is considered as independent of the organs, and as merely filling

* Dav. Ch. Schobinger. *De telæ cellulosæ, in fabricâ corporis humani; dignitate.* Gott. 1748.—Fr. Thierry. *Ergo in celluloso textu frequentius morbi et morborum mutationes.* Paris. 1749, 1757, 1788.—W. Hunter. *Remarks on the cellular membrane, etc, in Med. Obs. and Inq. vol. II.* London 1757.—Th. de Bordeu *Recherches sur le tissu muqueux ou l'organe cellulaire, etc.* Paris 1767.—Fouquet and Abadie. *De corpore criboso Hippocratis.* Monsp. 1774—C. F. Wolf. *De tela quam dicunt cellulosam observationes, in nova acta Acad. Sc. Imp. Petrop.* vol. vi, vii, viii, 1790, 1791—M. Detten. *Beytrag etc. viz.* supplement to the study of the functions of the cellular tissue. Munster, 1800.—S. H. Lucæ. *Annotationes circa telam cellulosam, in obs. circa nervos, etc.* Franc. ad Moen. 1810.—G. M. de Felici. *Cenni di una nuova idea, sulla natura del tessuto cellulare.* Pavia, 1817.

the spaces between them, while the other relates only to the organs it envelops and into whose texture it enters. These portions or divisions are distinct, in imagination only, for the cellular tissue is every where continuous with itself.

§ 137. The first portion is the external, general or common cellular tissue—*textus cellularis intermedius, seu laxus*—that which does not penetrate into the organs. This common cellular tissue has the general extent and form of the body; if we could suppose all other organs to be removed, and that this tissue could support itself, it would form a whole, preserving the form of the body and presenting a number of cells or cavities for the different organs. The thickness of the layer it forms round each of the latter, is not every where the same. In the vertebral canal the cellular tissue is but in a very small quantity; in the interior of the cranium, it forms an almost invisible layer, so great is its tenacity. More of it is found on the exterior of these same parts: it is particularly abundant about the spine, in front, especially. The different parts of the face, the orbits, the cheeks, contain a large quantity. There is also a great deal in the neck, along the vessels and between the muscles, in the thorax between the layers of the mediastinum, and on the exterior of this cavity round the mammæ. A great quantity of cellular tissue is contained in the abdomen, both in its interior, and in the thickness of its parietes. This tissue abounds in the groin, axilla, among the hamstrings, in the palm of the hand and the sole of the foot; between the muscles it forms layers, more or less thick. Generally speaking, it is the more important organs that are most surrounded by the cellular tissue; this tissue is also most plenty in those places that are the seats of great motions. Besides as it envelops all the organs and every where forms the partitions that divide them, other circumstances being equal, there should be most of it wherever these organs are most numerous: accordingly, this is what we find, in the neck.

§ 139. The continuity of the cellular tissue is particularly apparent in the great spaces between the organs. In the neck, the continuity of this tissue with that of the head above, and

with that of the interior of the thorax below, is evident: the openings of this cavity which communicate with the superior members, present an equally well marked continuity of the cellular tissue of the chest with that of the superior members. In a similar way in the abdomen, the ischiatic notch, the inguinal ring, the crural arch, &c. present, an evident continuity of the cellular tissue within the abdomen and without, and hence with the inferior members. The intervertebral foramina along the vertebral canal, establish a communication between the interior and exterior of the canal; the foramina at the base of the cranium establish in like manner a communication between its cavity and the outside of the head. The continuity of the cellular membrane does not only exist in the places of which we have spoken; various phenomena, of which more hereafter, indicate it generally in all the spaces that subsist between the organs; it is only more strongly marked, wherever these spaces are most sensibly defined. It will easily be perceived that the rounded forms of the organs, must render these spaces very numerous.

§ 140. The second division of the cellular tissue, furnishes to each organ in particular, an envelope which is peculiar to it, and which besides penetrates into its thickness; this peculiar disposition, has given rise to two sub-divisions. The cellular tissue which forms the envelopes of organs—*textus cellularis strictus*—has been considered by Bordeu as a kind of *atmosphere*, which limits their morbid action and phenomena, and prevents these latter from being extended from one to another. This idea, adopted by Bichat, appears to me to have but a slight foundation; the difference of their organization is the sole cause of the *insulation* which the organs present in their actions, as well as in their diseases. Be this as it may, the cellular layer which surrounds the organs varies in thickness—they all show this in a degree more or less marked, those only excepted, whose envelopes are of a different nature, that is, of the ligamentous or serous tissues. The envelope which this layer constitutes, is continuous with the common cellular tissue on the one hand, and with that which occupies the interior of the organ, on the other. Its cellular envelope is variously

disposed, according to the form of the latter. The skin, the mucous and serous membranes, the blood vessels, lymphatics and excretory canals which have only one surface free, are connected with the cellular tissue on one side only; the solid organs on the contrary, such as the muscles, are entirely surrounded by it. Under the skin the cellular tissue forms a layer generally extended, if we except the places where the muscles and aponeuroses are inserted. This sub-cutaneous tissue is more or less dense, according to the region it occupies; it is the most so throughout the whole extent of the median line, at the neck excepted, where this line is but slightly defined. Bordeu has exaggerated this disposition in saying that it divides the body into two halves: it is very evident, that at a certain depth no traces of it are to be seen. In those places where there is great motion, the cellular tissue is more lax, as in the eye-lids, prepuce, scrotum, lips and vulva. On the contrary, where the skin does not slide, as in the palm of the hand, the sole of the foot, front of the sternum, back, &c. it is tighter. The mucous membranes have their adhering surfaces covered by a very dense cellular tissue, usually styled the nervous membrane. That which covers the adhering surfaces of the serous membranes is generally flaky. That which is found round the canals, forms particular sheaths for them, particularly important to the arteries, but it is also found about the veins, lymphatic trunks and excretory ducts. This tissue forms a layer round the muscles, called their common membrane.

§ 141. That portion of the cellular tissue which penetrates into the organs, which accompanies and envelopes all their parts—*textus cellularis stipatus*—is differently disposed in the different organs. In the muscles it forms an envelope for each fasciculus, and smaller ones for the secondary fasciculi and for the fibres of which these latter are composed: thus the cellular tissue of a muscle exhibits a series of canals, sheathed successively within each other, and connected in the same way that the envelopes belonging to the different organs continue with the general envelope of the body. The lobes of the glands, their lobules, and the grains which compose these latter, are sur-

rounded in the same way by successively smaller, cellular envelopes, and which, apart from the rest of the gland, would form a sort of cellular sponge. The organs composed of several membranous layers, as the stomach, the intestine and bladder have cellular tissue between their different layers. Certain very compound organs, as the lungs, have more or less cellular tissue round each of the parts which enter into their structure: the quantity of cellular tissue is generally proportioned to the number of different parts that the organ contains. For in proportion as the cellular tissue is divided and subdivided to embrace the finer parts of the organs, it becomes itself finer, and its envelope thinner; thus it is that the small arteries are surrounded by a finer tissue than the larger ones. The envelopes formed by the cellular tissue are in general thicker, in proportion as the parts execute more motions, hence the predominance of this tissue in the muscles over the glands. Certain organs, such as ligaments, tendons, bones and cartilages have no free and distinct cellular tissue in their thickness. In order that it be apparent, it is necessary generally that the organs present appreciable intervals between their component parts: thus the ligaments which have apparent fibres, show the cellular tissue that separate these fibres—in the others none is to be found.

§ 142. Not only does the cellular tissue enter into the composition of all the organs, it also forms the basis of them all—*textus organicus*, *seu parenchymalis*—and composes per se, several of them: this it is, or the fibre or substance that forms it, if you will, that constitutes (varying only in degrees of consistence) the serous membranes, the dermis, the vessels, the ligamentous tissue, in a word, almost all the parts, with the exception of the nerves and muscles, even these, differ from it only in the addition of the globules. The horny and epidermic parts, alone have nothing in common with the cellular tissue. Haller and some other anatomists have placed the spongy or cavernous tissues and aerial vesicles of the lungs in the cellular tissue; but these parts have a peculiar disposition, which will not allow them to be confounded with the cellular tissue. The cavities of the hyaloid membrane,

also, included by Haller in the tissue of which we are speaking, should be distinguished from it.

§ 143. Anatomists have not yet agreed on the internal conformation of the cellular tissue. Some of them, with Haller, considering it as having distinct cells, of a determined form and size, made by the multiplied intercrossings of laminæ and filaments. Others again, as Bordeu, Wolff, and Meckel, say that this tissue is merely a viscous, tenacious, coutinuous substance, unfurnished with laminæ and cells, and that these latter, when they do exist, are the result of the operations made to demonstrate them. The following is what we learn upon this subject by inspection.

When we examine the section of a muscle by the glass, we perceive that the fibres are not in contact, but are separated by a transparent substance; if we draw aside these fibres, this substance forms filaments, which are extended as we draw, and finally break. Those who look upon the cellular tissue as a sort of gluten, take this opportunity to remark, that it would be precisely thus, if these fibres were separated by glue. Around the entire muscle, we find an evident lamina, which, in the same way, by distension, takes the form of filaments; by blowing air under this lamina, it is transformed into irregular cells, separated by species of partitions. It would appear then, that round the smaller parts, the cellular tissue, is really a sort of jelly, while around the larger, its laminæ are apparent. If, instead of air, we inject water, and freeze it there, irregular crystals filling the cells are obtained: a similar result follows the injection of a coagulable matter. But these cells are never regularly disposed, nor are their forms geometrical, as has been said; their figure may even vary, when produced at repeated trials in the same spot.

Whether the laminæ, fibres, and cells, are pre-existent in the cellular tissue, or whether they depend only on its separation, is a question, on which, as we have seen, there is much doubt. Possessed of a sufficiently distinct organization, wherever its thickness is considerable, this tissue seems inorganic in those places where it is thinner, and even different between the smaller fibres of the muscles. In admitting the existence

of the cells, should we regard them as closed on all sides, and communicating only after the rupture of their walls, or as pierced or porous cells, opening into those adjoining, or finally, as areola, spaces open on all sides, like those irregular ones, which subsist between the fibres and laminæ of the cellular tissue? The latter appears the most probable. But these areolæ in their ordinary state, are of an extreme smallness, microscopic with contiguous parietes, and the enlargement they experience by infiltration, inflation, etc, tearing and altering them greatly, can give no exact idea respecting them.

§ 144. The cellular tissue, in other respects, is precisely as though it were spongy, liquids and gases penetrating it with the greatest facility. In fact, 1st, the serum, in the dropsy of this tissue, always flows into its most depending parts, or into those which offer the least resistance; the situation of the patient has much influence, as to the place it occupies; external pressure displaces it equally; one single incision often suffices for its issue; 2d, the water thrown in by artificial injections, flows through the cellular tissue in the same manner from cell to cell; 3d, air infiltrated in emphysema, and that which is artificially introduced, present the same phenomena; 4th, in echymosis, the blood is infiltrated in a similar way, spreads extensively through the cellular tissue, and is disseminated more and more. All this demonstrates a general communication between the areolæ: those who do not admit these to exist, explain these facts by the slight consistence of the cellular tissue. Whether the areolar fibres or lamina, of the cellular tissue, be inherent in this tissue, or are only the effects of the various agents of distension, it is always certain, that in this respect, it presents remarkable differences. In certain places it is always fibrous or filamentous; in others, it is chiefly laminated, or lamellated, as in the eye-lids, scrotum, prepuce, the labia of the vulva, and between the very moveable muscles; the more soft and lamellated, the larger are the areolæ it forms; and these large areolæ seem to be the first rudiments of the serous cavities.

§ 145. When in thin lamina the cellular tissue is colourless; it appears whitish when its thickness is increased, and particu-

larly when distended; it is semi-diaphanous. Its powers of cohesion varies; in some places, as between the muscular fibrilli, it is simply that of a slightly viscid liquid; in others again, its resistance is almost equal to that of the fibrous tissue. This tissue is very extensible, and very retractile, as may be seen by inflating it, and making an incision, it then contracts forcibly, driving out the distending air. Its chemical properties have been carefully studied by Bichat. Deprived of water by dessication, it loses a part of its physical qualities, and acquires new ones; in this state, it is hygrometrical, and resumes its original aspect when placed in water, a peculiarity it possesses in common with almost all the organic tissues. Exposed to heat it dries rapidly, becomes crisp, and ends in burning like all the other tissues, leaving, however, but little ashes. It strongly resists decoction, and is dissolved only by long continued ebullition. It putrefies very slowly: to accomplish the entire decomposition of this tissue, by maceration, requires several months, even without renewing the water; it is converted at last into a viscid substance resembling mucilage, and furnishes divers products which rise to the surface of the liquid. Fourcroy considered it composed of gelatin; John detected in it besides, a small quantity of fibrin, and the phosphate and carbonate of lime.

§ 146. The intimate nature of the cellular texture, has given rise to a great number of hypotheses. Ruysch supposes it to be entirely vascular; Mascagni, who scarcely mentions it, says it is composed of white vessels; Fontana of tortuous cylinders; others regard it as an expansion of the nerves. The only base we should admit in it, is the cellular fibre or substance, 68, 85. It is traversed by a great number of vessels, and serous vessels particularly; but it should not be considered as wholly consisting of them, for it is it that definitely forms the parietes of the extreme vessels. The cellular tissue has canals or cavities peculiar to it. They are the little spaces or areolæ with which it is hollowed, or that the liquids excavate as fast as they are deposited in it, and which by their communication make it a spongy and permeable body. Almost all those who have paid particular attention to injections, Haller, Albinus, Prochaska,

&c. have placed it among the solid or non-injectable parts, *q v. d.* that it is without the circulating track of the vessels. The blood, nevertheless, may pass into its canals or peculiar cavities, but then there is inflammation. The nerves, in like manner, do not appear to stop or terminate in the cellular tissue. This tissue forms a true and separate substance, traversed by nerves and blood-vessels in every direction, and in which a liquid is left by the latter only.

§ 147. It is, in fact, continually bathed and humected by a very tenuous liquid, which it imbibes, and whose quantity is so small as to be scarcely sensible; the word vapour is consequently used to designate this fluid. If we make an incision, in the cellular tissue of a living animal, it is this liquid that moistens the fingers; introduced into the wound in cold weather, a vapour arises from the divided tissues, that is condensed and rendered visible by the external air; it arises both from the cellular tissue and the white vessels. In anasarca, the liquid of the cellular tissue, accumulated, and perhaps altered, greatly resembles the serum of dropsical patients; it is coagulable like the latter, and appears even to contain a certain quantity of albumen, water, and some salts.

§ 148. The cellular tissue is the first part formed in the embryo; it is also found in the very lowest order of animals. This tissue, at first liquid, and very abundant, diminishes in proportion as the organs become developed, and acquires consistence at the same time. Even at birth, it is still diffluent in the interstices of the muscles, and very soft under the skin. Its density continues to increase in old men, and it is almost fibrous at a very advanced age in those parts which in the infant are very soft. The cellular tissue is looser and more abundant in women than in men. Blumenbach, gives as a character of the organization of man, compared to that of other animals, the presenting of a softer and tenderer tissue, which gives him a greater facility of motion.

§ 149. The power of formation of the cellular tissue is highly developed: it is the first part formed; it increases accidentally, is completely formed at once and is reproduced when it has been destroyed, with the greatest promptitude, as is

seen in wounds, adhesions, &c. It possesses a power of contraction depending in part, upon its elasticity and partly upon its irritability. This latter quality is here called, fibrillary, staminal, tonic contractility: it is manifested by the motions of the liquid this tissue generally or accidentally contains, and by the general or local tightening it experiences in various cases; it is not very evident that the nervous force influences or determines its contractions. It has no sensibility except in a state of inflammation.

§ 150. The uses and functions of the cellular tissue are very important; it is it that determines the form of all the parts. It is the only lien that unites them with each other: upon its cohesion depends that of all the other tissue. By its elasticity, it facilitates the movements and replaces the organs in the state they were in previous to being displaced, when these movements have ceased: thus also do these latter perform their functions the more easily in proportion as the cellular tissue is perfect.

It is the seat of- a perspiratory secretion which on account of its extent is very abundant. Does the liquid there given out by the extreme vessels experience a sort of circulation or movement of translation? Of this we are totally ignorant. It is only in cases of morbid accumulation, that we see the infiltrated liquid change its place in obedience to weight and pressure, &c. It has been supposed, but without any solid reason, that this liquid is in a state of continual agitation, of which the diaphragm, by its alternate motions upwards and downwards, is the principal cause; that there are currents in various directions and that, for example, it is the secret way by which liquids pass from the stomach to the bladder, a supposition disproved by all exact observations; that it is the channel of metastasis, &c. However it may be, the liquid is afterwards taken back again by the vessels, so that this tissue is intermediate between perspiration and resorption. The tonic contraction of the cellular tissue is the agent that propels the serum of this tissue into the vessels.

The cellular tissue is in fact the essential organ of absorption; it forms the mucous body of the skin, the spongy sub-

stance of the villosities of the mucous membranes, parts which absorb, and whence, absorbed substances pass into the vessels. Previous to being brought into the vessels, the matters obsorbed by the cellular tissue, which by way of opposition to the rest we may call external or superficial, no doubt undergo elaboration or changes. As foreign matters, before entering the vessels, have to pass through the cellular tissue, the organ of absorption, so also those which are thrown out from the vessels, traverse the cellular tissue, the organ of secretion, previous to being deposited on the surfaces on which they are poured.

The cellular tissue which envelops each organ in particular, has been considered as forming for it an isolating atmosphere, which circumscribes its actions, whether hygid or morbid: observation frequently contradicts this assertion, and when the fact is so, it is in the peculiar texture of the organ and the variety of agents, that we must seek an explanation, and not in this pretended atmosphere.

The cellular tissue which penetrates into the thickness of the organs, reunites all their parts.

As to the organic cellular tissue or parenchyma, it forms the base or essential element of each organ, and presents these remarkable differences. In the most rational hypothesis respecting the seat of nutrition, it is admitted that the nutritive matter is deposited out of the vessels in the cellular substance, which is the base of the organs, to be assimilated to them, and that it is thus, the essential organ of nutrition. However it may be as to the hypothetical uses, attributed to the cellular tissue, it has incontestably very important ones in the organism.

§ 151. The phenomena of the cellular tissue either in health or sickness, are connected with those of the other parts. Thus organic lesions of the heart, and the derangements of the pulmonary respiration and perspiration, often occasion there an accumulation of serum. The same thing takes place in the alterations of various secretions, that of cutaneous transpiration particularly. Its inflammations, generally cause fever. The suppurative inflammation which is occasioned in it by

seton, &c. frequently reduces the inflammations of the other organs.

§ 152. The cellular tissue is subject to various morbid changes. When broken into and exposed, it inflames, becomes covered with *fleshy* buds, suppurates, and at last covers it with a cicatrix or new skin which will be described hereafter. (*Chap.* iii.)

When it is cut and its divided surfaces are again brought into contact, they, at first, agglutinate by means of a liquid poured out from the divided surfaces when the bleeding and pain have ceased. A little later, and this organizable substance becomes a highly vascular tissue: then it is no longer possible to separate the lips of the wound without renewing the pain, and reproducing the flow of blood. This new tissue remains for a long time, more compact, firm and vascular than the cellular tissue it unites and with which it is at last confounded.

It is by a similar process that every union of divided parts takes place, with modifications relative to each tissue, which will be examined in their proper place.

It is, also, in this way that adhesions are formed between contiguous surfaces of the serous and tegumentary membranes, adhesions that will be described when we come to treat of membranes. (*Chap.* ii, iii.)

The cellular tissue is susceptible of an extroardinary growth: when exposed, it sometimes shoots out in a kind of vegetation or vascular exuberances. The reproduction of this tissue is in general so much the easier, as the quantity that remains in the spot from which it was taken is great: it seems that this reproduction depends, in a great measure, upon the extension of the pre-existing cellular tissue.

The inflammation of the cellular tissue, or phlegmon, is characterized by various changes in this tissue. The first of these changes, is a highly marked increase of vascularity. The inflamed cellular tissue becomes, besides, sensible and painful; it entirely loses its permeability; liquids can no longer pass through it; its consistence augments and its tenacity diminishes; pressure tears and breaks, instead of elongating it,

as before. This sort of fragility which the cellular tissue acquires, explains certain phenomena; it explains why the ligature of a vessel frequently produces a section of the surrounding tissue, why at the termination of peritonitis, it is so easy to separate the intestine from the coat formed by the peritoneum. Inflammation of the cellular tissue may terminate insensibly, and then this tissue gradually reassumes all its properties: this is seen in that kind of termination called, by resolution. In other cases the cellular tissue secretes a peculiar liquid called pus, and which will be described hereafter—this constitutes the termination by suppuration. This liquid is generally collected in one point which extends itself progressively to the circumference, as long as the secretion continues. This is one of the perspiratory kind of secretions; pus is produced directly from the blood and even presents in its composition some analogy with this fluid. It only requires the disease to progress slowly, for the walls of the abscess to become lined with a membrane. This membrane is doubled externally by a layer, more or less thick, of compact cellular tissue. This layer is not so well marked when the disease has lasted a certain time, and the membrane is then almost completely isolated, the cellular tissue having reacquired its properties around it. Abscesses are the seats of a continual secretion and absorption; the entire absorption of the pus they contain, and the effects which the presence of this fluid sometimes produces in the economy are proofs of it. The pus formed in the interior of abscesses most commonly arrives at last at the surface. The abscess is emptied, its walls are contracted, remain indurated for some time, and end by reassuming all the characters of cellular tissue. When the secretion and flow of pus continue, the canal by which the abscess communicates without, and which is called sinus or fistula, becomes invested with a distinct membrane, that presents the characters of the mucous membranes, and whose history belongs to that of the latter. After certain gangrenous inflammations the cellular tissue becomes so tightened by the loss of substance it has undergone, that the skin, the muscles, and the aponeuroses become confounded: but in this case, if the pa-

tient is young and robust, the cellular tissue can be reproduced with all its properties. The inflammation of the cellular tissue sometimes continues for an indefinite period, so that it remains hard and impermeable: this constitutes induration. This state is found in the callosities of ulcers and fistulas, which are evident results of a chronic inflammation of the cellular tissue. The Barbadoes disease, a species of elephantiasis, presents similar characters of induration.

New-born children are subject to an induration of the cellular tissue, in which the inflammatory character is not found: this induration is observed under the skin, and sometimes in the spaces between the muscles. It is according to the observations of M. Breschet, merely a secondary phenomenon of the imperfect closure of the foramen ovale, or of a defective or imperfect respiration.

Air may pass into the cellular tissue; this constitutes emphysema. When the patient does not die from this accident, the rarified air escapes through the incisions made for that purpose, or through the wounds that may have previously existed, or it may combine with the fluids found in the cellular tissue, and disappear by absorption. Leucophlegmatis or anasarca, consists of an accumulation of serum in the cellular tissue. In ecchymosis, the cellular tissue contains blood dispersed through its areolæ. All the organic fluids may pass accidentally into this tissue, in which, when they are of an excrementitial nature, they occasion inflammations more or less violent.

Solid foreign bodies, introduced into the cellular tissue, do not, commonly, remain long in the same place, but like pus, are generally carried to the surface, and if they are heavy, partially obeying the laws of gravition. It is very evident, that it is not by traversing pretended cells, that these bodies travel thus across and through the cellular tissue. The latter presents around them, three distinct phenomena: it secretes pus around their surfaces, it re-unites and re-assumes its softness and permeability behind, and ulcerates before them. Here, then, we find three of the kinds of inflammation admitted by John Hunter, viz: the adhesive, suppurative, and ulcerative: the ensemble of these phenomena has received the name of eli-

minative inflammation. It sometimes happens that foreign bodies remain in the cellular tissue, either on account of the lightness of their specific gravity, or of the density of the surrounding tissue: a membrane, in this case, is formed around them.

The cellular tissue contains, in some cases, foreign animated bodies or worms: the *cysticercus cellulosa*, so called on account of its seat in the cellular tissue, the *filaria medinensis*, or little dragon, whose existence can not be questioned, have been found in it, and in animals the larvæ of the œstrus.

The cellular tissue may experience various changes. The serous, fibrous, bony, and cartilaginous transformation, which are developed in the cellular tissue, will be described with the natural tissues to which they belong.

The cysts, whose seat is in the cellular tissue, will be likewise spoken of, when treating of the serous and tegumentary membranes, to which they are very analogous.

When an organ happens, accidentally, to disappear, we say it is transformed into cellular tissue; this is, perhaps, not exactly correct; the cellular tissue in this case merely taking the place of the wasted organ, which previously kept it at a distance.

Various degenerations may be regarded as especially appertaining to the cellular tissue: it is this tissue which appears to be their base, for they are every where similar. As they are common, however, to all the organs, I shall speak of them when I have done with the history of all the other tissues. Wherever, in the interstices of the organs, the cellular tissue is free, it is affected by these degenerations, as well as in the places where it constitutes a part of the organs themselves.

SECTION II.

OF THE ADIPOSE TISSUE.

§ 153. The adipose tissue, so called on account of the fat (*adeps*) it contains, results from the re-union of very small, microscopic vesicles, clustered and grouped in greater or less

number, united by laminous cellular tissue, and fulfilling the office of a reservoir for the fat. It is divided into two kinds: one is the common adipose tissue, or fatty tissue, properly so called; the other is the adipose or medullary tissue of the bones.

ARTICLE FIRST.

OF THE COMMON ADIPOSE TISSUE.

§ 154. This has been called the fatty cellular tissue, fatty membrane, web, tunick, adipose, vesicles, &c.: it has also been styled the fatty pannicle, because it forms a layer immediately under the skin.

§ 155. This tissue, for a long time, was confounded, with the cellular tissue, which was sometimes said to contain serum, and at others fat, and in the latter case, to constitute the fatty tissue. Malpighi, was one of the first who raised a doubt on this subject, and who saw the fat form a kind of grains attached to the blood-vessels. Swammerdam has also seen that the fat is a liquid oil inclosed in little membranes. Morgagni acknowledges, also, that the fat contains grains which he compares to those of glands. Bergen was one of the earliest writers who distinguished two kinds of cellular tissue, one of which, called by him *laminous*, corresponds to the fatty tissue. W. Hunter has given the distinctive characters of this tissue, characters afterwards acknowledged, and more or less exactly determined by Jansen, Wolff, M. Chaussier, Prochaska, Gordon, Mascagni, myself &c. Haller denies the existence of this tissue, admitting only the areolæ of the cellular tissue as parts containing fat; his opinion has been adopted by Bichat, M. Meckel, &c.; we shall see, however, further on, that this opinion is but slightly founded. The fatty tissue has been carefully described in several works,* and figured in some of them.†

* M. Malpighi, *De omento, pinguedine, etc. in ejusd. op. omn et posthum.*—Bergen, *op. cit.*—W. Hunter, *op. cit.*—Wolff, *op. cit.*—W. X. Jansen. *Pinguedinis animalis consideratio physiologica et pathologica.* Lugd. bat. 1784.

† Mascagni. *Prodromo della grande anatomia.*

§ 156. The adipose tissue presents appearances varying according to the places where it is examined. Under the skin it forms a layer more or less thick and everywhere extended. In the orbits, in the thickness of the cheeks, in the interior of the pelvis, front of the pubis, about the kidneys, &c., it resembles rounded masses. On the loose edge of the epiploon, in the epiploical appendages of the intestine, and on the level of the openings which are found on the exterior of the peritoneum, these masses are pyriform and pediculated. In the epiploon, the fat is disposed in fillets or ribands that follow the track of the vessels.

§ 157. Although the fat, is not so universally distributed as the cellular tissue, it is nevertheless, found in many places.

The vertebral canal contains a small portion of it outside the dura-mater. It exists in considerable quantities about the head, particularly in the face, in the parotid notches, in the cheeks, &c. In the neck this tissue is more abundant behind than before. In the external and internal parts of the thorax it exists in remarkable quantities in the vicinity of the heart, as well as between the pectoral muscles and about the mammæ. The fat of the abdomen is principally situated outside the kidneys, in the pelvis, in the thickness of the mesentery, of the epiploon and of the appendica epiploicœ. In the limbs, fat is more abundant about the articulations in the direction of the flexion, as well as in those places that are exposed to constant pressure, as the nates and the sole of the foot.

The fatty tissue varies according to the organ in which it is placed. That which is under the skin always remains, cases of extreme emaciation excepted, and is continued into the areolæ of the skin. There is none found under the mucous membranes. The synovial and serous membranes, on the contrary, are lined by this tissue, particulary in the thickness of their folds. The adipose tissue which surrounds the muscles, penetrates likewise into the thickness of those that are divided into distinct fasciculi, as the great glutœus, &c. In the lobulate glands it is seen in the spaces between the lobes. The sheaths of vessels, generally contains but little. The large

nerves as the ischiatic nerve have small masses of it between their fasciculi. The fat in the bones is considered separately.

§ 158. In particular parts no fat is to be found, as under the skin of the cranium, of the nose, of the ear, of the chin, where the median line is entirely deprived of it; there is also but very little between the skin and cuticle. Scarcely any is found opposite the insertion of the deltoid, occasioning that depression which exists in even the fattest subjects. This fluid is not to be found, about the long and thin tendons, nor in the spaces of those muscles which produce the great movements, as between the triceps and anterior rectus femoris, the biceps and the brachialis externus, the gastrocnemii and the soleus. The substance of the viscera has seldom any fat, nor is there any in the parietes of the stomach, or of the uterus, in the liver or the spleen. The eye-lids, the penis, the small labia pudendi, are also deprived of it. The quantity of fat existing in the human body, greatly varies; but in some parts of it none can be found, not even in the most excessive state of obesity, while on the contrary there are others, in which the most complete marasmus never cause it to disappear entirely. In the adult man of ordinary plumpness, the fat forms about the twentieth part of the weight of the body.

§ 159. The fatty tissue is generally of a yellowish white colour and of a soft consistence, but varying according to the region to which it belongs, the age, &c.

§ 160. Whatever be the external form of the adipose tissue, the masses it presents are divided into smaller ones, from the size of a pea to that of a filbert, smaller about the head, larger round the kidneys. These masses are buried in the cellular tissue; their form varies; generally rounded, it is elongated, ovoid on the median line of the abdomen, one of the extremities holding by the skin, the other by the aponeuroses. By dissection we can reduce them into adipose lobules or grains, which examined microscopically, appear themselves to be composed of an infinitude of little vesicles, from the sixth to the eight hundredth part of an inch in diameter. We may then consider the fatty tissue as composed of conglomerate vesicles, united in grains, which in their turn, are collected to

form masses. The result of this disposition is that the structure of this tissue is not areolar, but rather resembles that of the fruits of the family of the hesperides, such as oranges and lemons which present in the same way, and very plainly, membranous vesicles attached to partitions that divide them. The fatty vesicles, as well as the grains and the masses which they form, are furnished with small foot-stalks, formed by the vessels situated in the intervals, and may be compared, in this respect, to grapes supported by their pedicles. These vesicles, however, are so excessively thin that it is impossible to distinguish their parietes; but there are many certain proofs of their existence. In fact, if the fat were loose or free, it would not form regular and distinct masses. It is an error in Haller and others to pretend that this form is proper to fat or inherent, for it presents no globules, and by itself has no determined figure. If we place under the microscope, some of these vesicles plunged into warm water, no oil can be seen on their surface; but on breaking them, a few drops of it escape and float on the surface of the liquid. Add to these considerations, that the fat in the living body being fluid, as is proved by its flowing on the division of the tissues, it ought to pass through like serum, if not in health, at least in disease; but this never takes place, and all that has been said about the infiltration of fat to explain the formation of the pendent mammæ of certain nations, the salient buttocks of others, the dorsal humps of some animals and the immense tails of others, &c., presents only a collection of contradictory facts and absurd reasonings. Roose and Blumenbach have argued against the existence of these vesicles, from the development of fat in parts were these little apparatuses do not exist; thence they conclude, that these latter are not necessary to the production of this fluid: fat is, in fact, produced in the cellular tissue, but it then forms vesicles, instead of being simply contained in the open areolæ.

§ 161. The cellular tissue between the adipose vesicles is very delicate, as it commonly is between the more tenuous parts of our organs: these vesicles seem scarcely to adhere to each other, as they may be separated without their opposing any resistance.

The cellular tissue becomes more distinct between the adipose grains and very apparent between the masses, the latter, in some places, even being separated by strong fibrous laminæ, as may be seen in the sole of the foot, and whose use is to give a high degree of elasticity to the fat. In other places, the adipose masses are united and supported by firm cellular laminæ, as in the cranium, back, &c. in others by a lax tissue as in the groin, &c. In order, however, to have a distinct view of the cellular tissue that is situated between the fatty lobes, we must examine it in subjects affected with anasarca or emphysema: by this examination we shall also be convinced, that the fat is not free in the areolæ of the cellular tissue; for however extensive, however deep be these infiltrations, they may separate, even dissect, as it were, the adipose grains, but the fat is never mixed with the infiltrated fluid.

The blood vessels of the fatty tissue are injected with ease. They are also very visible when we examine those parts, where the blood that remains fluid has been naturally carried after death. These vessels are most apparent in old persons, the fatty lobules being more distinct. Their divisions and sub-divisions end in microscopic vesicles. Malpighi once thought that these vessels were surmounted with a secretory apparatus, and a duct which emptied into the reservoir of the fat; he afterwards discovered and acknowledged that this disposition did not exist. The absorbent vessels of the vesicles are less known than the veins and arteries. Mascagni, it is true, says they are composed of an internal layer of lymphatic vessels, and of an external one of blood vessels; but he produces no fact in support of this opinion. It is not known whether or not these vesicles have nerves.

When there is no fat, there are no vesicles. When this fluid ceases to exist in a part, they disappear. Hunter says, however, that they may be distinguished even when empty; but I do not think this is so. Where they disappear, they become confounded with the cellular element.

§ 162. Human fat, extracted from the fatty tissue which contains it, and purified, by washing, fusion and filtration, has the general properties of fixed oils. It is inodorous, and

of a sweet and disagreeable taste; its yellowish colour is owing to a colouring principle that is soluble in water and carried off in washing. It is not so heavy as water, its fusibility varies according to its composition: it is, in general, fluid at the temperature of the body and under it, sometimes even greatly so, as at 15° R. for instance; it is insoluble in water, and but little so in cold alcohol: it is not acid; that which Crell admitted it to contain, is the result of distillation, an operation, in which fat gives out carbonic, acetic, and sebaic acids, with several other products of the reaction of its elements. It is converted into a sweet principle, and the margaritic and oleic acids, by the action of strong alkaline bases. Exposed to the air and light it becomes rancid, producing a volatile acid of a strong smell.

The elementary composition of several of the fats, has been determined by M. M. Berrarde, and Th. de Saussure; it is a combination of carbone, hydrogen and oxygen, varying in proportion, according to the kind of animal: that of human fat has not been determined.

Previous to the labours of M. Chevreul,* fat was considered as a simple principle. He has demonstrated that it is essentially formed of two organic materials; stearine, fusible at about 50° R. and elaine, fluid at zero; it is from the proportion of these, that results the degrees of fusibility of each kind of fat. These two direct materials are separated by treating the fat with boiling alcohol; by cooling, the greater part of the stearine is precipitated along with a little elaine, the latter remains in solution, in the alcohol, with a small part of stearine. We can also separate them by congelation, which first fixes the stearine with a little elaine. They may also be isolated by the absorption of unsized paper, which takes up the elaine and leaves the stearine on the surface.

§ 163. The fat of the adipose tissue, is not the only fatty matter found in animal organization, and in that of man in particular. A crystallizable fatty substance is found in the blood. Malpighi, Haller, and others, thought that free fat circulated with the blood: this is a mistake, at least, I have never

* *Annales de Chimie.* tom. xciv.—*Ann. de Chim, et de Phys.* tom. ii. et vii

seen it; but M. Chevreul has recently discovered in the blood, a fatty matter, held in solution by the other materials of that fluid. Butter is another fatty, coloured and odorous substance, held in solution in the milk. There is also in the nervous substance, a fatty, crystallizable matter, analagous to that of the blood. Finally, in cases of disease and cadaveric changes, other fatty matters are found in the human body.

§ 164. The adipose tissue, in animals, presents some differences; it exists in the greater numbers; it is found in the articulata, the mollusca, and the vertebrata. In the latter, the fat presents various degrees of consistence, colour, &c.; it is very fluid in fishes and the cetacea; the head of the physeter macrocephalus, contains a liquid oil, in which is found a concrete fatty matter, called spermaceti or cétine. In the hog it is soft, forming lard, firm in the ruminantia, where it is called tallow, &c. The volume of the adipose vesicles is not the same in all animals: according to Wolff, they increase successively, in the hen, the goose, man, the ox and the hog. Fat accumulates also, in different regions, in different animals, as on the back of the camel, the tails of some sheep, &c. The Bushman tribe is remarkable for the fatty protuberance of the rump in the women: an example of which has been recently seen in the *Hottentot Venus*, exhibited in Europe.

§ 165. The different degrees of plumpness establish great differences in the quantity of fat. In a complete state of obesity, it forms from the half to four-fifths of the total weight of the body. In extreme leanness, on the contrary it exists only in some places. Women have, commonly, more of it than men. It varies remarkably, according to age. The fœtus has none at all, until the period of gestation is half over. From this epoch to the birth, fat successively accumulates in the different parts. It is found at first under the skin only, and is there produced in isolated grains, which render its study at this age peculiarly easy. At birth, a large quantity is already found under the integuments, and in the thickness of the cheeks; the epiploon also, has some isolated grains of it. The quantity of fat, augments with the increasing growth, and ends by occupying the interstices of the muscles, but a long time elapses

before it is produced round the viscera. The state of maturity, or the period in which the growth is terminated, is that of obesity also: the latter is sometimes observable in children, but very rarely. In old age, the quantity of fat is diminished, chiefly under the skin : this fluid then exists, especially in the interior, as about the heart, in the medullary cavities of the bones, &c.

§ 166. The properties and functions of the fatty tissue, relate only to the secretion of the fat. This secretion is not made in particular glands, nor in ducts: Heister and Fanton were the first to doubt the existence of these glands, of which, since the error of Malpighi on this subject, many authors have spoken.* The secretion of fat is a perspiratory secretion, and Rigel was wrong in endeavouring to revive the theory of fatty ducts, which he did, at the same time he brought forward his hypothesis upon the use of the renal capsules: according to this author, the fat which surrounds the kidneys and its pelvis, is formed in these capsules, whence it is carried by particular ducts, which ducts, however, he had not been able to inject. Does fat directly result from the organic action of the vessels which deposit it in the adipose vesicles? or, is it already formed in the circulating blood? or has it a yet more remote origin? M. Ev. Home† fixes its origin in the intestine; he thinks, that like the chyle, it is a product of digestion, and that it is absorbed by the great intestine. This opinion is based, among other facts, upon the existence of the fat, or the yolk of egg, in the intestine of oviparous vertebrata, in the fœtal or larval state, and upon some morbid facts that are not very conclusive.

§ 167. The fat is continually taken up by the absorbent vessels; the action of these vessels is demonstrated by its diminishing in quantity in several circumstances. This action is equal to the secretion, when the quantity of fat remains the same. The exhalation and absorption of the fat, is occasionally very rapid, as proved by many facts. Children that have become emaciated, in consequence of sickness, resume all their

* *De usu glandularum superrenalium in anim. nec non de origine adipis disq. anat. philos.* Hasniæ, 1790.

† *Philosophical Transactions, ann.* 1813.

plumpness in a few days. Animals that are famished, such as hogs, very soon become fat. Certain birds fatten, it is said, in moist weather, in less than twenty-four hours; emaciation, in many cases is equally rapid. The circumstances most favourable to the secretion of fat, are castration, and the absolute rest of the animal and intellectual organs. These causes are frequently united when we wish to fatten animals: they produce a similar effect upon man. Habitual bleedings, sweet and amylaceous aliments, are also regarded as favouring the production of fat. Besides these, there are unknown circumstances, which appear to act in the same way, for we remark extraordinary cases of obesity, for which it is difficult to account. The causes which accelerate the absorption of the fat, are in general, the opposite of those above mentioned, in addition to which are, abundant secretions, organic diseases, and particularly those of the organs of the nutritive functions.

§ 168. Many hypothetical uses have been attributed to the fat. Those which it really possesses, are local and general. In fact, the uses of fat are in part purely mechanical, or of position, such as to lessen pressure, in the sole of the foot, in standing, in the buttocks while sitting, and jointly with the cellular tissue to fill up the hollows, and thereby give a roundness to the parts; thus we see those of women and children to be the most so, they having most fat. It has been said, that the fat served as a defence from cold, because this fluid is a bad conductor of heat, and that the animals which inhabit cold countries, have a thick layer of it under their teguments. Admitting this to be so, it is not by the surface of the skin, at any rate, that the fat could preserve warmth. It has been asserted, but without reason, that it lessened the nervous action, and the action of the muscles, i. e. the muscular energy and sensibility: in this case, cause has been mistaken for effect. The fat has been thought to supple the fibres. Fourcroy, remembering that this fluid contains an excess of hydrogen, thought it destined to render the nutritive substance more nitrated, by depriving it of a part of its hydrogen. Several authors, and even Bichat himself is inclined to the opinion, have thought that the fat might serve to oil the skin by a sort of porous

transudation: the sebaceous follicles are too well known at present, to permit us to adopt this idea. The general uses of the fat relate to nutrition. Previous to being assimilated, the nutritive matter passes successively through various states; fat is one of the forms it assumes. Moreover, this fluid may be considered as an aliment in reserve: of this various examples are seen in animals. Insects for instance are nourished by their fat while in their chrysalis state, and present the same phenomenon a little time before their death. This is still more strongly marked in the hybernating animals which sleep during the winter, and are nourished by their fat only, until they wake, at which period they are excessively lean. The fœtus of the oviparous animals are nourished by the fat which forms a great proportion of the yolk of the egg.

§ 169. The adipose tissue and the fat, besides the differences of which we have spoken, present some morbid changes.

When the fatty tissue is divided, small drops of oil escape and if the lips of the wound are maintained in contact, reunion soon takes place; but the fat reappears in the place of reunion, only, when the new cellular tissue has ceased to be compact. The denuded fatty tissue becomes inflamed, the fat is absorbed; it then covers itself with a layer of organizable matter, which becomes the base of the cicatrix or new skin that is formed over the fat.

This tissue and the fat it contains sometimes accumulate in great quanities, as is seen in obesity or polysarca. Individuals have been seen in this state weighing five or six and sometime eight hundred pounds. When the obesity is local, or limited to a part of the body it is called lipoma.* This disease may haye its seat any where; it is most commonly seen however under the teguments, and outside the serous membranes. Tumours of this kind seated under the skin, have been very improperly confounded with encysted tumours. Their figure is round; when very voluminous they push up and draw away the skin, and are then pediculated or pyriform:

* See Th. Ch. Bigot. *Dissert. sur les tumeurs graisseuses exterieur au péritoine, etc.*—Paris, 1821.

they have been found weighing from forty to fifty pounds. On the exterior of the serous membranes their figure is generally ovoid, one of their extremities being attached to the membrane, the other to the skin; outside the peritoneum this tumour constitutes the fatty hernia or liparocele. The structure of the lipoma is analogous to that of the fat; the vesicles, according to Munro, having the same volume as the latter, being only more numerous. A cellular envelope similar to that which surrounds the muscles, and which is sometimes so dense as to approximate it to the fibrous membranes and the cysts, is generally found round the tumour. This membrane contains vessels which are tolerably apparent. The lipoma, outside the peritoneum, when opened, sometimes exhibits the aspect of the epiploon: generally speaking however these tumours contain fewer vessels than others of the same volume.

Authors have spoken of fatty transformations of the mucles. The following is what observation has taught me on this subject. In palsy the muscles often become perfectly white; their fibres diminish in volume at the same time, and as this alteration is chiefly observed in old persons, in whom the fat is most abundant internally and as the part being at rest augments the quantity of this fluid, there results a fatty appearance of the muscles that has been mistaken for a true fatty transformation. But their proper fibrine is still to be found in them, by submitting them to the action of alcohol, or of an absorbant paper—when boiled in water or exposed to the fire. There is then merely a discolouration of the muscles, but no fatty transformation. M. Vauquelin and M. Chevreul, in the analysis they made of these muscles, obtained similar results. Neither does this fatty transformation exist in the bones. The marrow which occupies their interior may become more abundant. The liver is sometimes the seat of a fatty transformation that has not been sufficiently examined.

Inflammations which occur in regions where the adipose tissue is very abundant, have a peculiar tendency to terminate in gangrene. This observation, which has long been made upon the very fat animals, such as hogs and sheep, when they are stung, is equally correct as relates to man, in whom wounds

and infiltrations—stercoraceous or urinary ones particularly—in the fatty tissue, are followed by extensive gangrene. The very small proportion of living parts contained in the adipose tissue may account for these phenomena. Something analogous may be seen in hernia epiploicœ: if considerable masses of epiploon be left externally, this organ becomes gangrenous on its surface, abundance of oil flows from it, and when in consequence of this, its volume is considerably reduced, there remains a mere red and very vascular mushroom, formed by the cellular tissue intermediate to the fat and by the development of the vessels.

Dr. Traill, of Liverpool, in a case of hepatitis, found in the serum of the blood drawn by venesection, a remarkable quantity of oil, nearly two parts and a half to the hundred of serum. The cysts of the ovary frequently contain fat mixed with hair, and sometimes teeth, but the alteration is in that case very complex, and this is not the place to speak of it. Biliary calculi are sometimes formed of a fatty matter called *cholesterine.* Stercoraceous matters sometimes, also, contain fatty substances, either intermixed, or in separate masses. Ambergrease is a fatty substance that appears to come from the intestine of the *physeter macrocephalus.* Certain cysts of the genital organs and some hydroceles occasionally contain brilliant particles that are nothing more than cholesterine. This matter is also found, though less frequently, in morbid tissues situated in other regions. The tumours called meliceris, steatoma and atheroma, which are considered as subcutaneous, *Chap.* iii., contain a certain proportion of fatty matter.

ARTICLE II.

OF THE MEDULLARY, OR ADIPOSE TISSUE OF THE BONES.

§ 170. The medullary tissue is a membranous, vascular and vesicular tissue contained within the cavities of the bones. It has received the names of marrow, medullary system, medulla, meditullium, by a comparison with the pith of trees.

§ 171. Duverney* has made it the subject of several observations: Grutzmacher† and Isenflam‡ have given detailed descriptions of it. Every osteologist, and all those who have paid attention to the adipose tissue, have also occupied themselves with the medulla. Havers,§ particularly, has well described and figured its vesicular texture. Albinus has a beautiful plate of it in his *Annotationes Academicæ*, the vessels however are represented too large: Mascagni in his *Prodromo* has also given a good figure of the medulla.

§ 172. The marrow occupies the great medullary cavity of the bodies of the long bones, the cellular cavities of the short ones, of the extremities of the long bones, the thickness of the wide bones, and even the pores of the compact subtance of the bones. It is totally deficient in the sinuses and aerial cells of the bones of the cranium.

§ 173. The fat which occupies the medullary canal of the bones represents a cylinder moulded by the bony parietes of this canal, and is contained in a membrane called the internal or medullary periosteum. This membrane, whose very existence some have denied, while others considered it as being formed of two layers, is composed of one single leaf, easily perceived by an experiment, which consists in sawing a bone and exposing it to fire or plunging it in acid: the membrane becomes crisp, is detached from the bone and forms a distinct canal whose tenuity is such, that without this precaution it is almost impossible to see it. Its tissue can only be compared to that of a cobweb. This membrane lines the interior of the bone and appears to continue on to their extremities with the marrow that fills them. It sends off prolongations into the compact substance and furnishes inside an infinitude of similar parts, whose disposition, in general, resembles that of the filaments and lamina that compose the cellular membranes.

* *Memoires de l'Academie des Sciences*, 1700.

† *De ossium medullâ.*—Lips. 1754.

‡ *Ueber das Knockenmark, in beitræge, &c. Von Isenflamm und Rosenmuller*—B. II., Leipzig, 1803.

§ Clopton Havers. *Osteol. Nov.*—Lond. 1691. *et Obs. nov. de ossibus.*—Amstel. 1731.

These prolongations are supported by the filaments and lamina of the reticular substance, in those places where it exists.

§ 174. The composition of the medullary membrane, is principally owing to the vessels that are ramified in the interior of the canal, and which are supported by an extremely soft and hardly visible tissue: this membrane, in this respect, greatly resembles the pia-mater or the epiploon, and appears formed like them, by the cellular tissue belonging to the sheaths of the vessels. An artery and vein penetrate into the medullary canal, and as soon as they have entered it, divide in two branches, whose ramifications extend to the two extremities of the bones, and communicate with the numerous and large vessels of their extremities. The lymphatic vessels have been followed to the entrance of the medullary cavities only. Successful injections, on the contrary, show a multitude of coloured filaments in the canal of long bones. The nerves of this canal, whose existence has been denied, may be easily traced. Sœmmering, it is true, thinks that these nerves are destined for the artery only. These nerves have been particularly studied by Wrisburg and Klint. The medullary tissue is then essentially composed, 1st, of an arterial and veinous net-work, and probably of one of lymphatic vessels also: 2d, of a nervous plexus destined either for the artery, or the artery and other parts; 3d, of the cellular sheaths peculiar to these parts that give out fibrilli, whose re-union form a sort of incomplete, fringed, membrane. To this must be added vesicles, that are very apparent, but in the recent subject only, as in others they become much less distinct, owing to the rapidity with which the marrow becomes fluid. These vesicles are in every respect precisely similar to those of the adipose tissue in general; they have the same volume, and the same connexion with the blood-vessels, to which they appear appended. Grutzmacher, thinks that the texture of the marrow, and that of the fat generally, is areolar like the common cellular tissue, and not vesicular. The spongy extremities of the long bones contain a great number of vessels; but their membrane is less distinct than that of the middle of the same bones. There appears to be vesicles there, similar to those of the medullary

membrane. The pores of the compact substance appear to contain them also.

§ 175. The fat of the bones is called marrow, in the medullary canal, medullary fluid, in the spongy substance, and oily juice in the compact substance. This fat is formed of the same elements as all other fat, varying, however, in the proportions, being more fluid; it is also more highly coloured and yellower.

§ 176 The medullary membrane is sensible. Duverney has well pointed out the experiment, which proves this property, that Bichat has, perhaps, exaggerated a little, but which it is wrong to question. If, in fact, in the generality of the amputations performed upon man, the impression caused by dividing the bone is hardly felt, it is owing solely to the more violent pain, resulting from the section of the skin which has preceded it. But if in a living animal, we allow a sufficient interval to elapse between the section of the teguments, and the lesion of the marrow, so that the impression produced by the first, may have time to be dissipated, a stylet introduced into the medullary canal, produces a pain on the instant, which is testified by the animal in various ways; it will easily be supposed, that this sensibility resides in the membrane, and is foreign to the marrow itself. The nerves in the bone accompanying the principal medullary artery, if the bone is amputated above the entrance of this vessel, the remaining marrow no longer has any communication with the nervous centre; it is to this disposition that is attributable, the difference of sensibility observed by Bichat, between the centre, and the extremities of the medullary cavity, and also to the fact, that the nervous threads proceed in dividing themselves towards the two ends of this cavity. The medullary tissue is gifted with an obscure contractility, similar to that of the cellular tissue. The arteries, which ramify in this membrane, secrete and deposite the fat.

§ 177. The medullary membrane, according to Bichat, has an early origin, pre-existent to the canal, it is filled with a cartilaginous substance, which afterwards gives place to the marrow, as fast as ossification advances. The most attentive observation has discovered no arteries, veins, nor medullary

membrane, in the cartilages: at a later period, the cavity of the large bones is merely a narrow canal filled by the artery; when the canal begins to enlarge, the artery throws itself on the side, and fastens itself to the parietes; a viscid or gelatinous substance is then contained in the canal; marrow is finally produced in it, but in small quantities; in time, the canal increases in size, and the marrow becomes more abundant. As respects this tissue, there is no perceptible difference between the sexes. This fluid, presents individual differences as relates to quantity. In a state of ordinary plumpness, fat forms the greater part of the substance contained in the medullary canal. In eight parts of this substance, I have found seven of fat: the remainder is formed by the vessels, water and albumen. In lean subjects, on the contrary, the fat constitutes only a fourth, or even a less proportion of the fluid contained in the long bones: the remainder appears to me to be water, or at any rate an evaporable substance, and albumen, or a coagulable substance. According to Camper, there is air, instead of marrow in the cavities of the long bones of birds.

§ 178. The functions of the medullary tissue, are to serve as an internal periosteum, and as a reservoir for the fat: it is upon it that those vessels ramify, which are directed outwards on the one hand, to assist in nourishing the bone, and inwards, on the other, to produce the secretion of the fat. The latter, has the same uses as in other parts. Its local use is to fill up those spaces which without it would exist in the bones. It has been thought, and Haller and Blumenbach were of the opinion, that it rendered the latter more flexible, and less frangible; but the bones of children, deprived of fat, are, however, less frangible than those of adults, while the bones of old people, in whom this fluid is so very abundant, are in general very fragile. Those who have advanced this opinion, found it upon the fact, that combustion deprives the bony substance of all its solidity; it is evident, however, that in this case it is not the oil only which it loses, but the animal matter also, on which depended their solidity. The same authors add, that by boiling the earthy residuum, obtained by the combustion, in oil or gelatine, its solidity, to a certain degree, is restored; but a

peculiar compound is thus formed, a kind of stucco, that has no resemblance to bone. Haller and other physiologists have also thought that the marrow served for the reproduction of bone, and the formation of callus particularly. Observation, however, shows us, that fractures heal so much the more readily as the patient is young, and the less marrow there is, or the less fat the marrow contains. Duverney, and others, have considered the marrow as necessary to the nutrition of the bones; is a sufficient proof of the inadmissibility of this opinion, that many animals have none, as birds, and that deer's horns are deprived of it, that this fluid does not exist in infancy, and that the bones are formed before the marrow. The marrow has also been regarded as the reservoir of latent caloric, and of electricity. Marrow does not serve to lubricate articulating surfaces, for the synovia exists in many places where there is no marrow.

§ 179. The marrow undergoes some morbid changes.* While the bone is consolidating in fractures, the fat disappears in the medullary canal; the cellular tissue of this canal becomes compact, as in other cases of solution of continuity, and ends in ossification: this last fact, observed by Bichat, has since been verified by several observers, when the consolidation is perfect, the medullary membrane re-assumes its properties.

After amputation, the same phenomena are observed in the marrow, as in other wounds, affecting the fatty tissue: the oily matter disappears, and a cellular and vascular layer is formed at the truncated extremity of the bone which finally closes. The marrow is destroyed in the sequestra, and does not appear to be re-established after they are taken out; at least it has never been known so to do; perhaps the state of the parts has never been examined a sufficient length of time after the termination of the disease.

The medullary membrane is susceptible of inflammation: it is probable to this and its consequences, that internal necrosis is to be attributed. It is equally probable, that pains in the bones depend on this inflammation. A peculiar induration of

* *See* Moignon *Tentamen de morbis ossium medullæ.* Paris et Lugd. Ann. iii.

the medullary membrane is observable in rachitis which has not been described.

Among the affections peculiar to this membrane, spina ventosa is the most remarkable. According to my own observations and those of several others, there are two and even three distinct species of this disease. The considerable development of the bone arises from the extraordinary growth of the altered medullary membrane; but at one time the alteration in the marrow consists in a carcinomatous degeneration in a true, soft cancer; at another the tumour is fibrous and cartilaginous: in some cases, particularly in children, the bone enlarged in the middle, contains a highly vascular red substance whose nature has not been well determined this variety is particularly observed in the bones of the metacarpus, of the metatarsus and of the fingers. Spina ventosa particularly affects the long bones of the limbs: in the femur it is generally the inferior part of the bone that is diseased, in the humerus, the superior. I have taken away the superior third of the fibula in a young woman, in a case of spina ventosa, that had enlarged the head of the bone to the size of the patient's fist. Tumours of this nature have been described by Vignarous under the name of bony steatoma, and by Sir A. Cooper under that of medullary exostosis.

CHAPTER II.

OF THE SEROUS MEMBRANES.

§ 180. The membranes, *membranæ*, are soft, broad and thin parts that line the cavities, envelop the organs, enter into the composition of a great number of them and constitute others: they differ greatly from each other in their texture, composition, action, &c.

§ 181. The serous membranes, *membranæ serosæ, vel succingentes*, so called because they contain a great many serous vessels in their thickness, are humected by a liquid analogous to the serum of the blood, and because they furnish tunicks to many organs, form a system or numerous genus of membranes closed on all sides, adhering by one surface to the surrounding parts, loose and contiguous to themselves on the other, serving to isolate certain parts, to facilitate their movements, and resulting from a very simple modification of the cellular tissue.

§ 182. Confounded for a long time with the parts to which they are attached, the serous membranes have been particularly distinguished from other parts and studied in their ensemble by Bonn,* by Munro,† and particularly by Bichat.‡

§ 183. The serous system comprehends membranes which, by their numerous points of similarity, form a very natural genus, in which, however, there are sufficient differences to mark several divisions expedient. In relation to their situation, and to the more or less unctuous liquid which humects them, they are divided into serous membranes, properly so called, or serous membranes of the splanchnic cavities, and synovial; the latter are again divided into those of the articula-

* *De continuationibus membranarum.* Amst. Batav. 1763.

† *A description of all the bursæ mucosæ, &c.* Edinb. 1788.

‡ *Traite des Membranes.* Paris, an. viii.

tions, those of the tendons and those which are subcutaneous. We must first examine the characters common to all the genus, and then those of the species.

SECTION I.

OF THE SEROUS MEMBRANES IN GENERAL.

§ 184. All these membranes consist of bladders closed on all sides: there is no other exception to this general disposition, than the opening by which the peritoneum communicates with the genital organs in women, the continuity of these organs themselves being interrupted between the ovary and the commencement of the oviduct or fallopian tube. The result of the general conformation of the serous membranes, is, that the fluids they contain are entirely isolated, and that their membranes are only permeable by the vessels that ramify in their thickness, and not like the cellular tissue, by areolæ freely communicating with each other; this conformation presents, however, some secondary forms or varieties. Some of these membranes which are as simple as possible, resemble an ampulla or bladder; they are called vesicular. Others constitute sheathing envelopes that surround certain parts such as the tendons, ligaments and the blood vessels; and as they are not pierced so as to allow these parts to pass, but are reflected at their two extremities and so form a double sheath, they have received the appellation of vaginiform. This disposition is one of the most usual. There are some however that are still more complex; they are the enveloping serous membranes, those which more particularly merit the name of *succingentes:* these latter surround the organs except at one single point of their surface, about which they are reflected on to the parities of the cavity which contains them, and are thus divided in two portions, of which one forms an envelope for the organs, and is called the visceral layer, or tunic, while the other which lines the parietes, constitutes the parietal layer. The

different forms we have just examined, are often united in the same membrane. In the enveloping serous membranes, like in those which are found about the heart, lungs and testicles, there is always a spot on the surface of the organ deprived of this serous envelope; it is through this spot that the vessels of the organs penetrate, or that the organ itself is attached to the surrounding parts. This part, freed from organs covered with serous membranes, is sometimes considerable, at others, very narrow. In some instances the viscus is removed from the parietes which contain it, and is attached or suspended by a fold of the serous membrane which forms what is called a bridle or membranous ligament: this disposition is no excepception to what we have just said. There is always a part of the organ, not covered by the membrane throughout the whole extent of the surface to which the fold formed by the latter adheres. Besides this first kind of folds or plaits, the serous membranes present prolongations, that float more or less loosely in the cavity they form, and which most commonly depend on their visceral layer, but which sometimes belong to the others: the epiploon, the appendicœ epiploicœ for the peritoneum: the fatty plaits observed in the pleura on the sides of the mediastinum, for this latter membrane; the synovial fringes for the articulating capsules, are all examples of these prolongations. These latter always contain cellular tissue, generally fatty, within their substance: it is here also that the membrane presents most vessels.

§ 185. All the serous membranes have two surfaces, one free, the other adherent. The latter is flaky, and holds to the cellular tissue, to ligaments, tendons, cartilages, &c. Its degree of adherence to these different parts is more or less great: a loose cellular tissue sometimes produces it, while elsewhere as on the cartilages, it adheres closely. There is a multitude of intermediate degrees between these two extremes, as may be observed when adhering to ligaments, muscular fibres, tendons, &c. The free surface of the serous membranes is everywhere contiguous to itself: it is the interior of a kind of bladder that these membranes resemble. This surface, at the first glance, appears perfectly smooth and polished: but

microscopically examined, it presents manifest villosities: for this reason they have been styled, the simple villous membranes. This surface is constantly humected by a liquid.

§ 186. The serous membranes are generally of a whitish colour, which their transparency renders scarcely sensible, glistening on their free surface, extremely thin yet tolerably strong, more so in fact than the cellular tissue would be if reduced into lamina of an equal tenuity; they are commonly slightly elastic.

§ 187. They appear, at first sight nearly homogeneous: almost always, however, a fibrous appearance, more or less marked, may be observed in various parts of their extent. When torn by distension, they first become loosened, and then reduce themselves into little intermixed, intercrossed, and, as it were, interwoven filaments. Their nature appears very analogous to that of the cellular tissue, from which they only differ by their greater density and the distinct cavity they represent. Between the cellular tissue and the serous membranes, there exists a sort of insensible gradation, and the most simple of the serous membranes still partake largely of the nature of the cellular tissue. The very loose cellular tissue in which inflation develops large ampullœ, as that of the prepuce, that which exists between the great moving muscles and the subcutaneous synovial bursæ, constitute a transition between the two tissues. Very numerous white vessels enter into the composition of these membranes. Injections and inflammation penetrate the first with a coloured liquid; the second, the blood, in these vessels render the latter very apparent: their number then appears very considerable. We must not, however, confound the vessels peculiar to the serous membrane with those that belong to the subjacent cellular tissue, and which might be supposed to exist in the membrane itself, on account of its transparency. In the peritoneum, for instance, the inflammation must last for a long time to cause the blood to penetrate beyond the sub-serous cellular tissue; and on a slight observation one would be tempted to think it was the peritoneum itself rendered vascular by the disease. It is the same with injections; it is only when they are extreme-

ly thin that they penetrate into the membrane itself. The nerves of the serous membranes are not known.

§ 188. The liquid contained in these membranes is not the same in all; it resembles however more or less the serum of the blood or blood deprived of its colouring matter. It contains, in general, water, albumen, an incoagulable matter that may be considered a sort of gelatiniform mucus, a fibrous matter and soda. We shall see hereafter the difference presented by this liquid in the various species of the serous membranes.

§ 189. The serous membranes, during life particularly, are highly extensible and retractile, as is seen in dropsies and after the disease is cured: but their enlargement is not always the result of their extensibility; their folds disappear, which being gradually developed, serve to aid the increase of the membrane. Another cause which assists in this augmentation of volume, is the sliding of which this is susceptible, the species of locomotion it experiences when it is distended in one part only, as is particularly seen in hernia. There appears also in some cases a real increase of nutrition, which contributes to the production of this phenomena: this augmentation, with the other causes of ampliation is manifested in pregnancy. These phenomena are not all equally marked in the different species of serous membranes: the peritoneum presents them in the highest degree; they are much less so in the synovial membranes, the articulating ones particularly, which partly arises from the less extensible nature of these membranes, and from their having fewer folds, and above all from their connexions which do not permit them to displace themselves with the same facility. When the distension has ceased they gradually return to their original state, but if it has proceeded to a very relaxed state, traces of it always remain.

§ 190. The force of formation, tolerably well developed in the serous membranes, is less so in them, however, than in the free cellular tissue. Their mobility is very limited, extending only to the feeble degree which constitutes tonicity. But if irritation does not occasion in them any perceptible movements, it develops sensibility there: in fact these membranes

become very sensible and generally, in inflammation transmit painful impressions.

§ 191. All the serous membranes are the seat of the constant deposition and absorption of a serous liquid in their cavity or in their free and contiguous surface. The great extent of these membranes, taken together, gives great importance to this double function. The matter of this secretion, like all the others, is brought by the vessels into the thickness of the membrane, and particularly into its most vascular points, the fringed prolongations: by what way the secreted matter leaves the vessels and passes into the cavity, is not exactly known. Secreting glands have been supposed for all these membranes, either in their vicinity or in their own thickness—but no such glands exist. Transudation by organic pores, has also been supposed; but without exactly knowing the mode in which the perspiratory secretions are performed, we know that transudation takes place in the dead body only, and then even some time after death. The liquid is also continually absorbed by the membrane, in the thickness of which it re-enters the vessels. While the deposition and absorption remain in equilibrium, the serous membranes are simply moistened on their surfaces. The augmentation of the secretion or the diminution of the absorption, gives rise to an accumulation called dropsy.

The secreted liquid has local uses and general uses: locally, it serves to preserve the separation between the two contiguous layers of the serous membranes and to facilitate the motion of the organs over one another; generally, it is probable, that the nutritious matter thus alternately deposited and taken up becomes more perfectly assimilated, previous to its employment in nourishing the organs.

§ 192. The action of the serous membranes, in health and in disease particularly, is closely united with those of the other organs. Thus, when they are diseased, the functions of the organs they invest are more or less disturbed, and this disturbance extends to a distance, and often to the whole organism; in the same way, affections of other organs particularly those of the tegumentary membranes, of the circulating

organs, and of the glands, frequently derange their functions; the affections of the organs they invest always produce a corresponding one in them, more or less evident; on the one hand, the cavity they form establishes a complete isolation between the parts on which their opposite portions are reflected; on the other, the continuity and extent of these membranes, easily give rise to very extensive affections.

§ 193. At its origin, about which however little is known, the serous system is very soft: in the embryo the abdominal viscera seem covered with a mere viscid and liquid varnish. The serous membranes are very thin in the fœtus, and in general less adhesive, on account of the softness of the cellular tissue which unites them to the neighbouring parts, so that they are easily separated from these latter: in the articulating cartilages, however, and in the albuginea of the testicle, the adhesion is almost as great as at a later period. We are completely ignorant whether or not these membranes, whose essential character is the interruption of continuity they establish between the parts, are at first a soft cellular tissue, continuous and without an internal cavity, as is affirmed by some anatomists, who admit that in the beginning, there exists a general continuity of all the parts; among the bones, for instance. The liquid of the serous membranes is at first very thin; some of these membranes, those of the splanchnic cavities, present in the fœtus remarkable differences of conformation. In old age the serous membranes undergo various changes.

§ 194. The conformation of an accidental serous tissue is frequently observed; its reparatation or reproduction takes place in wounds of the serous membranes, which reunite when their edges are in direct contact; observation has shown the opinion of the ancients, who did not believe this kind of wound susceptible of reunion, to be totally void of foundation. When these wounds are attended with loss of substance, or when there is a separation of their edges, the space is filled up by a new membrane, a true cicatrix; this appears a little thinner and more extensible than the surrounding membrane.

§ 195. The liquid contained in the cavity of the serous membranes is susceptible of accumulation either from the ab-

sorption being diminished or the exhalation being increased: this accumulation produces various dropsies. The liquids formed in the latter, presents various qualities, particularly if there is inflammation. This fluid sometimes contains more animal matter than is found in a state of health, at others less: sometimes the proportion of this matter is the same as in that state. Generally speaking, the serosity of dropsies resembles the serum of the blood, except in having a less proportion of albumen. There is one point of pathological anatomy to which sufficient attention has not been paid; that is the dropsies which do not appear to depend upon an alteration of the serous membranes or of the organs of respiration and circulation, and which for this reason have been regarded as general affections, are often preceded and accompanied by a flow of urine containing a great proportion of gelatine and albumen, a substraction of animal matters which alter the composition of the blood, which renders it more watery and which is owing to an alteration of the kidney and its function. This flux sometimes also accompanies dropsies with a local affection of another viscus.*

§ 196. Inflammation of the serous membranes, which is a very frequent occurrence, produces in these membranes, changes in their tissue and in their secretions. The membrane becomes vascular at first in its external cellular tissue, and after a while in its own thickness; its vascular fringes and villosities are better marked, and finally become more prominent and very thick. If the inflammation continues for a certain time, the membrane becomes thickened and loses its transparency; this thickening, however, which appears very great, is generally in appearance only and is foreign to the membrane itself. Besides the interstitial arrangement which gives rise to this alteration, a secretion takes place in the cavity of the membrane itself; the secretion however, is at first suspended, afterwards to be renewed with a change of character. The liquid poured out, is, as the case may be, either a simple and abundant serum, but not materially altered, or a

* *See* T. Blackall, *Observations on Dropsies, etc.* London, 1813.

whitish lactescent fluid, or containing albuminous and fibrinous flakes; sometimes, though rarely, the serum is bloody; finally, pus is to be found in it, having all the properties of that produced in the cellular tissue. Besides these effects of inflammation, there are others which are very remarkable.

§ 197. The false membranes, the *pseudo membranæ*, are not peculiar to the serous membranes, but are frequently found there. They consist in the concretion, under the form of a membrane, of the product of the secretion of the membrane, inflamed to a certain extent. This product, similar to the organizable matter which determines the adhesion of the lips of wounds, is at first thrown in separate drops on the free surface of the membrane; these drops, by their multiplication and extension, generally meet, forming first a net-work, then an entire surface. Most commonly the same thing takes place on the opposite side of the membrane and the latter generally remaining in contact with the former, the false membrane occasions the agglutination of the two parts, previously contiguous: this is the first degree of adhesion, the gelatinous adhesion of some, and the plastic adhesion, *adherence couenneuse* of others; I prefer calling it agglutination. At one time the agglutinating matter merely forms a thin layer interposed between the approximated surfaces, at another, it is so abundant, that it fills and distends the serous cavity.

Organic adhesions of the serous membranes, are a frequent result of the formation of false membranes. The organizable matter of the agglutination, is converted into cellular tissue, in which are formed ramifying canals, which gradually acquire the vascular structure, (*chap.* iv.) and which end by communicating with the vessels of the inflamed membrane. Several of the first observers, who saw the vessels of the adhesions, mistook them for vascular villosities, prolonged from the old membrane into the matter of the false one. J. Hunter and M. Ev. Home, have observed the contrary, a fact, the truth of which I have several times proved. By pricking, at random, a recent adhesion with a tube filled with mercury, we can inject the ramifying canals, whose largest part or trunk, corresponds with the centre of the adhesion, and whose branches

diverging in opposite directions, like those of the *vena porta*, are directed towards the serous surfaces, without always arriving there, and without the latter presenting any well marked villosities. In time, this disposition changes, as soon as the canals have communicated with the old vessels, the adhesion becomes more and more vascular in the vicinity of the membrane, and less and less in its centre. Organic adhesions of the serous membranes, have not always the same form, they consist, generally in bridles or cords, larger at the adhering extremities, and smaller in the centre which is free; at other times, there is a great number of filaments nearly similar to the bridles; in other cases, the adhesions are so multiplied, that the two parts of the membrane are confounded, and seem to be replaced by the cellular tissue. The texture of the adhesions, as seen in the bridles, is that of the serous membranes; they form a sort of smooth sheath, filled with cellular tissue containing some vessels. These adhesions are on the one hand so frequent, and on the other so regularly organized, that many of the ancient physicians took them for natural ligaments, and that among the moderns, Tioch has found some of them in the pericardium, and Bichat in the pleura, that appeared to them to belong to an original conformation.

The bridles or bands which form the adhesions, lengthen as they harden, it is even probable that in the end, their centres are completely absorbed; what inclines us to this belief, is, that in examining the parietes of the abdomen, soon after wounds of this part, we generally find the intestine adhering to the place of the wound, while at a more distant period, the adhesion is merely formed by a bridle, which at last becomes itself very thin; and finally, that if we observe the disposition of the parts, at the end of a very long period, we find no adhesion whatever. These different degrees, were all found in the body of a patient, I dissected, who was affected with melancholy, and who had stabbed himself with a knife twelve or fifteen times, at different periods of his life.

§ 198. The serous membranes undergo several transformations, or to speak more correctly, are the seat of various accidental productions. Fibrous, cartilaginous, fibro-cartilaginous,

and even bony plates, are frequently observed in their thickness, particularly in the pleura, which sometimes forms a sort of shield in consequence of chronic pleurisy. These plates, are generally, it is true, subjacent to, or laid over them.

Free or pediculated concretions have their seat in the interior of these membranes. They are found, more particularly, in the articulating serous membranes, sometimes, however, in those of the tendons, and even in the splanchnic cavities. They are at first external to the membrane, and afterwards pushing it gradually before them, they project into its interior, where they present a wide and short base, and at a later period, a pedicle which becomes longer and longer, until finally breaking, they become perfectly free in the cavity of the membrane. Such is the true mechanism of the formation of these bodies, that have been taken for true concretions, when they had not been observed in their different stages of devélopment. The consistence of these bodies varies: sometimes they are very soft and albuminous, but most commonly they are fibrous, cartilaginous or bony.

The serous membranes participate in the degenerations common to all the tissues; they appear, also, to be subject to some that are peculiar to them.

§ 199. Vices of conformation are to be observed in some of these membranes, as in the arachnoid membrane of the anencephalous fœtus, in the peritoneum and vaginal tunick, when the canal of communication between these two membranous sacs subsists after birth. A kind of supernumerary sacs have been found in the peritoneum: Neubauer gives some examples: Acquired vices of conformation are also peculiar to a small number of these membranes, and belong to special anatomy. Hernia is one of these vices.

§ 200. Cysts may with propriety be described along with the serous membranes: it is in fact with this genus of organs that they have the greatest resemblance. They resemble, in general, like all the parts comprised in the serous system, a pocket or membranous cavity, closed on all sides, adherent on one surface, free on the other, and in contact with a liquid which fills it: they are commonly of a globular form; their

volume varies from that of a grain of millet to that of the distended abdomen; here we find them isolated, and there several grouped together and communicating with each other; their external surface is floculent, cellular, sometimes having laminæ, or even a fibrous layer; sometimes this surface is lined with a natural membrane which they have encroached upon in sallying towards a surface; their internal surface is smooth and polished: the thickness varies, and is in general less in the cysts of the organs, than in those of the free cellular tissue; it is also greater or less in different parts of the same cyst; the consistence varies from that of a barely concrete liquid, to that of the serous and even of the fibrous tissue; it is the same with their adhesions which are sometimes very close, and at others seem to be a simple agglutination: there are no apparent vessels on their free surface.

The liquid they contain is not less various. At one time, we find it a serum, either limpid or more or less thick like albumen, variously coloured; at another it is fat, either fluid, or in particles forming cholesterine; in some cases it is mucus or a viscid substance, which, instead of coagulating by heat, evaporates almost wholly, leaving but very little residuum; in others it is a mixture of mucus and albumen, or a blackish matter resembling chocolate, sometimes even pure blood; at others hydatid worms; sometimes crystallized saline substances: a concrete substance has also been found there, resembling caoutchouc.

The cysts are in a state of repletion that may be compared to the dropsies of the serous membranes: they are the seat, however, of a continual secretion and absorption; they disappear in certain cases, persist in some, and continually increase in others.

Different theories have been proposed to explain the formation of cysts. Some authors regard them as membranes of a new formation which are developed round an originally existing substance; others again, on the contrary, think they are pre-existent to the matters they contain, whether they be formed by the distended cellular tissue, or owe their production to the dilated lymphatics. It is difficult to say, exactly, which of

the two opinions are right. There are cases that favour each of them. Certain tissues that are classed with the cysts, are evidently pre-existent. In this class we may place the subcutaneous wens, which are nothing more than sebaceous follicles, considerably enlarged, and not accidental sacs, the cysts of the ovary, which appear to depend upon the extraordinary development of the vesicles of that organ, the cysts of the testicular cord of man, or of the labia pudendi of woman, which are the remains of the tunica vaginalis, &c. Another genus of cysts, are, on the contrary, formed consecutively; such are those which follow the effusion of blood which occur in the brain, those which are developed around a foreign body, &c. In other cases it is very difficult to determine the mode and origin of cysts. It is very likely, however, that all true cysts are membranes of a new formation, determined or not by an evident inflammation. The cysts are, besides, subject to all the affections of the serous membranes, to all the varieties of inflammation, to accidental productions either analogous or morbid. They have been found every where, in bones and cartilages, perhaps, excepted.

The new cellular membranes, which envelop accidental, analogous, or morbid accidental productions, and foreign bodies, are generally confounded with cysts. These envelopes are not like the cysts and the serous membranes, inhalant and exhalant surfaces; they often line the cysts. Their consistence varies: they are also always parts of a new formation.

Between the cysts or serous vesicles, holding to the cellular tissue by their external surface, and the hydatids, there are insensible transitions, between which it is very difficult to draw a well defined line of demarcation. Thus the little serous vesicles, that are so often found in the plexus choroides, those which are sometimes seen at the fringed extremity of the fallopian tubes; those which I have frequently seen in the vegetation of the nasal and uterine mucous membranes, all evidently appear to belong to the cysts. The hydatid or clustered mole appears to me to belong to the same genus, yet a very able physician and naturalist,* refers it to the genus acephalo-

* *See* H. Cloquet. *Faune des médicins*, tom. i. Paris 1822.

cyst. The three species of simple acephalocysts themselves, whose animality is yet doubtful, approximate in a certain degree to the cysts. I have taken from under the skin of the neck, and several times from under the skin of the mammæ, acephalocysts of these species that were single, not encysted, not adhering, it is true, but agglutinated to the cellular tissue. Most commonly we find one or the other of the three species of simple acephalocysts, assembled in great numbers and free, in a distinct cyst.

A modern physician* has attributed the origin of tubercles, of all tumours, and even of all foreign bodies suspended or free in the serous and synovial cavities, to the formation, development and transformations of the hydatids, or hydatiform cysts of which we have been speaking.

After having given the general history of the serous system, we must describe in succession the various species which compose it.

SECTION II.

ARTICLE I.

OF THE SUB-CUTANEOUS SYNOVIAL BURSÆ.

§ 201. The synovial or mucilaginous sub-cutaneous bursæ, *bursæ mucosæ sub-cutaneæ*, had not been described by anatomists. Some pathologists, and particularly Gooch, Camper, and lately M. Asselin, have spoken of their dropsy, and while treating of this, Camper has a word upon their healthy state. I have examined and described them for a long time in my lectures; I have also mentioned them in the additions to the general anatomy of Bichat, and in the Dictionnaire de Médecin.

§ 202. The synovial bursæ, whose rudiments are partly seen in the loose and very extensible cellular tissue, which exists between all the very moveable parts, are found under the skin, wherever that membrane covers parts that exercise great

* *See* J. Baron. *An inquiry &c. on tuberculous diseases.* London, 1817.

and frequent motions; as between the skin and the patella, the olecranon and the skin, on the trochanter, on the acromion, before the thyroid cartilage; sometimes behind the angle of the jaw; always between the skin and projecting side of the metacarpal and metatarsal articulations, and between those of the first and second phalanges. All these latter are generally confounded with the neighbouring tendons.

In order to have a good view of these membranes, we must fill them with air. It is then seen that they form an obround, multilocular cavity, that is, a cavity divided by incomplete, but closed partitions, the air blown into it, remaining shut up there, and not passing into the surrounding cellular tissue; the walls of the cavity they form are very thin and weak.

Their texture is very simple, like those of the serous membranes generally, and appears to differ from that of the cellular tissue, only by a little greater density. There are but very few vessels in the thickness of these membranes: their free and contiguous surface is humected by an unctuous or mucilaginous liquid, in such small quantities, as to preclude the possibility of its being properly examined.

The local use of these membranes and the unctuous liquid they contain, is evidently to facilitate the motion of the bones under the skin.

These bursæ are developed at a very early period; they exist at the time of birth, and are then easily perceived on account of the greater abundance of the liquid that moistens them.

Their development augments in proportion to the exercise of the parts they cover; that of the acromion, for instance, becomes more apparent in individuals who carry burdens on the shoulder; that of the knee is most developed in those who are habitually kneeling.

§ 203. They are formed accidentally, in those cases where the skin exercises accidental rubbings. M. Brodie speaks of a gibbosity, on which one was developed in consequence of the continued sliding of the skin: the same thing is observable in club-foot in the spot where the skin rubs against the salient side of the tarsus; and again, the same result takes place after

amputation of the thigh, between the end of the bone and the cicatrix.

Dropsy of the sub-cutaneous synovial bursæ, constitutes hygroma, an affection known to the ancients, that is observed particularly in the knee, before the patella of persons who habitually rest on it, such as priests, nuns, the washerwomen of certain countries, servants who scrub in that posture, sweeps &c. and that is also occasionally, but less frequently seen in the other membranes of the same species. Hygroma may acquire considerable volume. It sometimes suddenly disappears without any known cause, or after medicinal applications. I have sometimes punctured it, and withdrawn a viscid serum. A stimulating injection, after the fluid is abstracted, often produces a mutual adhesion of the walls, and an obliteration of the cavity.

The sub-cutaneous synovial bursæ are susceptible of inflammation, of suppuration, and the formation of large abscesses, either from reiterated pressure, or from injections.

ARTICLE II.

OF THE SYNOVIAL MEMBRANES OF THE TENDONS.

§ 204. The synovial membranes of the tendons, *membranæ mucosæ tendinum*, are serous membranes, moistened with an unctuous fluid, annexed to the tendons in the places where they rub against the neighbouring parts.

They have received the improper names of bursæ, bladders, capsules, of mucous, mucilaginous, synovial sheaths, &c. They have long been known: Vesalius and A. Spigel mention some of them. A certain number have been accurately described by Albinus. Jankius was the first who gave a general description of them; he was acquainted with sixty pairs. Camper was the first who gave a figure of one of these membranes. It is to our celebrated Fourcroy,* as well as to Munro,† that

* Hist. de l'Acad. R. des Sciences. Paris, 1785, 1788.

† *A description, etc. with tables.*

this part of anatomy is most indebted. Koch* has well described these membranes, not in man only, but in several animals. Gerlach† was the first who described and figured, well, those that are found in the neck and head. Rosenmuller‡ has given a work on them, augmented by that of Munro. Mascagni has given a good figure of one of these membranes in his *Prodromo*.

§ 205. The number of these membranes is considerable, but various; at this day we know about one hundred pairs. Like all the serous membranes, they form membranous cavities without openings; but with reference to their form, they are divided into two kinds. The first are rounded vesicles holding on one side to the tendon, and on the other to the part on which they slide: these are called vesicular. The others are vaginal, surround the tendon circularly, and another part line the canala in which it is contained, these two isolated parts joining at their extremities so as to be separated by a space that constitutes the cavity of the membrane. Among these latter there are some, which are simple at one end, presenting digitations at the other which answer to a similar number of tendinous parts or different tendons, these latter, at first united, afterwards separate from each other: this is seen in the wrist under the annular ligaments.

§ 206. The cellular tissue, loose and membraniform, which is found between those muscles that produce the great and continued movements, as under the latissimus dorsi, the rectus anticus of the thigh, the muscles of the calf, &c., constitute, in some sort, the rudiments of the membranes in question. Synovial membranes are found round the tendons in those places where the latter rub against the bones, slide along their surfaces, or on other parts, or where they are reflected and change their direction: these membranes sometimes exist between two tendons that move on each other. The glutæus

* Ch. M. Koch. *De bursis tendin. muc.* Lips. 1789.

† F. E. Gerlach. *De bursis tendinum mucosis in capite et collo reperiundis. cum tabul. æneis.* Vitcberg, 1793.

‡ *Icones et descript. bursar mucosar. corporis hum.* Ed. T. Ch. Rosenmuller. Lipsiæ, 1799.

maximus, at the spot where it slides on the trochanter, the obliquus major of the eye at the place where it is reflected in its pulley, the lateral peroneals where they alter their course to reach the sole of the foot, &c. are all furnished with synovial membranes. Generally these membranes are connected with bones or fibrous rings. They are very common about the articulations, because, it is there especially that the tendons are situated. This is seen in the wrist, the knee, &c. We there find the two kinds of which we have spoken. Some of these capsules are confounded with the sub-cutaneous or articular synovial bursæ: that of the triceps for instance, is not always isolated, and frequently appears like a continuation of the synovial capsule of the knee.

§ 207. The adhering face of these membranes, besides being attached to the tendon and the part on which it rubs, is connected, in the space between both the cellular and fatty tissues; it is often attached to fibrous tissue, as for instance, to tendinous or fibro-cartilaginous sheaths, as in places where the tendons slide upon bones, and in which place the periosteum is like cartilage. Generally their interior presents a simple cavity, sometimes a compound one, traversed by partitions, a kind of fibrous prolongations. Fimbriated prolongations are found in some, in that situated behind the calcaneum for instance, we also find there small fatty or cellular masses, but in those only that are formed like vesicles; those that are vaginal contain none. These prolongations have been assimilated to excretory ducts. Rosenmuller describes follicles in these membranes—I have never seen any there. They contain villosities which pour out synovia.

§ 208. The synovial membranes of the tendons are whitish, semi-transparent, thin and soft, those that are vaginiform particularly, the latter having also external ligamentous sheaths. The vesicular bursæ are thicker, and present in some places a fibrous appearance. The texture of these membranes is the same as that of the others of the same genus; their tissue greatly resembles the cellular tissue. The fibres, the fringes and adipose masses, common to all the serous system, are also found here. Serous vessels which become visible in inflam-

mation and some blood vessels particularly apparent in the fringes, enter into the composition of these membranes whose lymphatics and nerves are entirely unknown. The liquid they contain is viscid, more abundant than in the sub-cutaneous mucous bursæ, yellowish and sometimes reddish; it is oleiform, partly coagulable, and contains albumen and mucus: it is more viscid in the mucous bursæ which are the most extensive. Mr. Koch has found some difference to exist in this liquid, as examined in different animals, as in the ox, the horse and the hog.

§ 209. The properties of the tendinous capsules have nothing particular. Their functions are to secrete and contain a mucilaginous liquid, which facilitate the sliding by diminishing the loss of motion which results from friction.

But little is known respecting the development of these membranes. According to some, they are greatest in number in young subjects, and by increasing in size and meeting each other, they become partly confounded in old age. M. Seiler, on the contrary, asserts that they diminish in extent in old persons, and partly disappear.

§ 210. They undergo some changes.* Dropsy is an affection not very rare in them, those which are in the neighbourhood of the skin are particularly liable to it; this may occasion the disease to be confounded with hygroma. The name of ganglion is given to the little circumscribed tumours resulting from it, and which are often cysts also. These tumours are particularly met with in the hamstrings, wrist, foot, &c.; they contain a serous, albuminous, yellowish or reddish liquid, similar in colour and consistence to currant jelly. The absorption of this liquid is effected very slowly: it is accelerated by crushing the tumours that contain it, as this disperses it in the cellular tissue. These tumours are occasionally found much larger; voluminous collections of purulent serum that have been observed under the great muscles of the back, under the deltoid, &c. and which have been confounded with the com-

* Monro, *op. cit.* Koch. *De morbis bursarum tendinum mucosarum.* Lips. 1790.

mon abscess of the cellular tissue, are seated in membranes of this kind or in those analogous to them.

Inflammation of the membranes of which we are treating is a serious matter; it may be observed in one of the varieties of paronychia. The results are adhesions or an abscess which opens externally, and in either case the power of motion is destroyed. When the adhesion is filamentous it is sometimes finally removed. Chronic inflammation produces nearly similar results: it may also induce suppuration.

Solid cartilaginous bodies have been found in the interior of these membranes by Munro, and since by many others. We frequently find in them, a great number of small bodies resembling apple or pear seeds in size and shape, that have been considered as animated and for which the name of *acephalo cystis plana*, has been proposed. They have been most often found under the anterior ligament of the carpus, and sometimes also in other membranes of the tendons, as in those of the great gluteus, of the long flexor of the thumb, &c. An incision gives them issue, but the general result is a very serious inflammation and at all events an intimate adhesion, which, in the wrist, for instance, confounds all the flexors in one single bundle, and renders the fingers motionless. The inflammation of the synovial tendinous membranes generally, merits the attention of pathologists. It is the same with the greater part of their morbid changes, which have often, under the name of white swellings, been confounded with diseases of the articulations, in whose vicinity they are situated.

ARTICLE III.

OF THE ARTICULAR SYNOVIAL CAPSULES.

§ 211. Under this name, *capsulæ synoviales* are designated, the serous membranes of the diathrodial articulations. Most of them belong to the bones, some to cartilages, as is the case with the larynx. These membranes, like the preceding ones,

are humected by a liquid internally, and impart a similar facility of sliding to the parts they invest.

For a long time they were confounded with the capsular ligaments of the joints. Nesbit, Bono, and W. Hunter had already observed that they formed a membrane distinct from the articular ligaments and cartilages. Monro had remarked their analogy to the other synovial and serous membranes; Bichat has fixed our attention more particularly upon these membranes, and has given a more complete general description of them. Monro and Mascagni have figured them.

§ 212. The number of these membranes is very great, being about equal to that of the articulations. This number is not quite equal to that of the latter, because, on the one hand, some of these membranes are common to several articulations, as in the carpus, for instance, and on the other, some of the articulations contain several membranes. They are found, however, in the articulations only.

§ 213. The following varieties are observed in the configuration of these membranes: 1st, some resemble simple, rounded sacs, like the vesicular membranes of the tendons: this is seen in the articulations of the phalanges with each other and with the metatarsus and metacarpus: here is nothing at all complex, and a small round ampulla is all that is attained by insufflation. 2d, in some articulations, the cavity of the membrane seems to be traversed by a ligament or tendon about which this is reflected, forming for it a sheath, continuous at its two extremities with the common envelope, that the synovial membrane furnishes to the articulations; this synovial membrane is then vaginiform: this disposition is found in the coxo-femoral, scapulo-humeral articulations, &c. 3d, a greater degree of complication is observed in some other articulations; in that of the knee, for instance, we perceive a common envelope, sheaths for the tendon of the popliteal muscle and the adipose ligament, and folds moreover invest the semi-lunar and crucial ligaments, which raise up the membrane and project into the articulation. We might then establish, nearly the following order in the complication of the synovial membranes: simple ampulla; an ampulla raised up by fatty flakes; this last

disposition joined to the presence of sheaths; lastly, besides this latter, folds formed by parts which extend into the articulation, and that are covered by the membrane. All these forms, which are so various, are to be referred finally to the vesicular form.

§ 214. The external surface of the synovial membranes is more or less intimately connected with the neighbouring parts. They all adhere closely to the articulating surfaces of the bones, or rather to the cartilages which invest them, by the two extremities of the kind of sac they represent. Their connexion with these cartilages is so close as to occasion a belief that the latter is naked: Nesbit, Bonn and W. Hunter, however, long ago announced the existence of a prolongation of the synovial membranes, upon the articulating surfaces of the bones. It is to Bichat in particular, that we are indebted for having, incontestably, established this truth. Some authors, however, such as Gordon and M. Magendie, still raise doubts on the subject. Many facts demonstrate the presence of the synovial membranes on the cartilages. When these membranes are inflamed, their redness, which in time becomes apparent, extend around the circumference of the cartilage, and becomes less and less sensible as it advances towards its centre, the membrane becoming more and more identified with the cartilage; the centre itself is finally penetrated with vessels, but the cartilage is coloured only at its surface, preserving in its thickness the whiteness peculiar to it. The bridles which are sometimes formed in the synovial membranes arise, indifferently, from all parts of their extent, and it is observed that when they adhere to the cartilage, their bases are less closely united to it, and that in this place, the membrane becomes apparent as it naturally is about the articulating surfaces: in this manner, the synovial membrane becomes apparent even on the centre of the cartilage. The fungous degeneration peculiar to the synovial membrane is also to be found on the cartilage. Finally direct inspection demonstrates the continuity of this membrane. By obliquely raising a slice of cartilage, and afterwards bending it back so as to break it at its base, it still holds by the synovial membrane which covers it equally with the rest of the cartilage.

When a bone is sawed, break the cartilage at its extremity, and the connexion is still kept up between the two halves by the synovial membrane which extends from the one to the other.

Throughout the remainder of their extent, *i. e.* on the edge of the articulation, the synovial membranes are attached to the articulary ligaments, in an equally close way as is seen in the scapulo-humeral articulation: the adhesion is particularly intimate in the middle and becomes looser towards the extremities. In the intervals between the ligaments, these membranes correspond to the fatty and cellular tissues: these tissues form distinct pellets there as well as near the place where the synovial membrane leaves the ligaments to be reflected on the bones.

The internal surface is smooth, polished, contiguous to itself, lubricated by the synovia, and furnished with villosities and fimbriated prolongations.

§ 215. The synovial membranes are thin, soft, semi-transparent, whitish, extensible to a certain degree, although less so than the splanchnic serous membrane, and retractile, a fact demonstrated by their dropsy and their return to their original dimensions after the evacuation of the accumulated fluid. Their rupture in relaxations depends less on their want of extensibility, than on their close connections and the small extent of their folds.

§ 216. These membranes are provided with fatty pellets placed on their exterior or even in their interior, and improperly called the *synovial glands of Havers.* These pellets, perceived by Vesalius and Etienne, described by Cowper and particularly by Cl. Havers,* until the time of Monro, were regarded as the secreting organs of the synovia.† Their size varies according to the quantity of fat they contain: they always contain more or less of this fluid, and are almost entirely formed of adipose tissue. The fringes exist on the inte-

* *De ossibus,* sermo iv. chap. I.

† *See* Pitschel. *De axungiâ articular.* Lips. 1740.—Hanse. *De unguine articulari, ejusque vitiis.* Lips. 1774.

rior of the membrane, at the spots where the pellets are placed without. The points in which these different objects are found, are those where the membrane is most vascular. The fringes contain in their thickness, cellular tissue, fat and blood vessels: the other parts of the synovial membranes only receive serous vessels. Lymphatics are apparent in some of these membranes only; it is useless again to revert to the theory of Mascagni which this author applies to all the transparent membranes. The nerves of the synovial capsules are not known.

§ 217. The liquid secreted by these membranes or the synovia, *synovia,* so named by Paracelsus on account of its imperfect resemblance to the white of egg, is the result of a perspiratory secretion, although various other opinions have been entertained about the mechanism of its formation. This fluid is not, as it was for a long time thought to be, the product of a mixture of serum and fat; the marrow of the bones does not transude to form it as we have seen; the synovia, in its natural state does not even contain any oil. The supposed glands of Havers can not, from what we have said, fulfil the functions ascribed to them, and the fringes that surmount them, are not, as he thought, excretory ducts: it is but very lately, however, that this glandular structure has been supposed to have been found; in fact, nothing glandular can be observed in the synovial masses, no granulations nor excretory ducts.* Even the fat they contain is not essential to their structure, and besides, as there is no oil in the synovia, it is not from the transudation of the first of these fluids, when it exists, that the second owes its origin. Rosenmuller pretends that there are secretory follicles in these adipose pellets: I have never seen these follicles, nor do I know that any one since has proved their existence. The secretion of the synovia then, is neither glandular, follicular, nor a simple result of transudation, but truly perspiratory; it has its seat throughout the whole extent of the synovial membranes, that portion of them, particularly, which surmounts the fringes, and which

* *See* Heyligers, *Dissertatio physiol. anat. de fabricâ articul,* 1803.

is owing to the great number of vessels it contains. The synovia is partly taken up by absorption, and its quantity in a normal state, being always about the same, supposes an equilibrium between absorption and secretion.

This liquid known to the Greeks who called it μυξω των αρθρων, and long known as axunguia, is viscid and has a saltish taste; its specific gravity is 105, that of water being 100. Its chemical composition has been examined in animals as well as man, but more particularly in the ox by Margueron, Fourcroy, T. Davy, Hildebrandt, M. Orfila and several others. There are found in it water, albumen, mucus or incoagulable matter, considered by some as mucilaginous gelatine, a thready matter, which some think is fibrine and others albumen in a particular state, soda, muriate of soda, phosphate of lime, and an animal matter said to be uric acid. The use of the synovia is to diminish friction and to facilitate thereby the sliding of the parts.

§ 218. The synovial capsules of the articulations present some pathological alterations.* They are repaired when divided; but their mode of reunion is not well understood; there are no precise facts in the history of wounds of the articulations, and of luxations, relative to it. New synovial membranes are sometimes formed as is observed in false joints, after unreduced luxations; in this case, described by Dr. Thompson and observed by myself, the remains of the old capsule and the cellular tissue united, form a new membrane very similar to the first. In false articulations, which succeed to fractures that have not been consolidated, there is also found a closed membrane, smooth within, containing a viscid liquid more or less analogous to the synovia.

Dropsy of the joints constitutes hydrarthrosis; in this affection, the synovia undergoes various changes.

§ 219. Inflammation produces the same alterations of tissue and functions in these, as in the serous membranes generally.

* *See* Reimarus, *de tumore ligament, etc.* Leyd. 1557.—Wynpersse, *de ancylosi.* Leyd. 1783.—*Ejusd. de ancyl. pathol.* Leyd. 1783.—Brodie, *Traité des maladies des articulations.* Paris, 1819.

They become a little thickened, redden to a greater or less extent, are covered with albuminous granules, and sometimes finally form adhesions. The inflammation may terminate by resolution, and it then leaves a stiffness, occasioned by the thickening of the surrounding parts: the membrane itself, also, generally remains thickened. Flowing of pure synovia, lactescent serum, or serum containing albuminous floculi, or even true pus, may also result from the inflammation. The adhesions it finally forms, constitute one of the species of anchylosis. There are, as is well known, several kinds of this disease: they all depend, however, upon the changes of the synovial membrane, and sometimes of the parts exterior to it. Thus in false anchylosis, there appears to be a thickening, an induration of all the parts surrounding the articulations. Another species, to which, if worthy of preserving, the epithet false, might be applied, is characterized by adhesions of the synovial membrane. The articulation then becomes an amphiarthrosis, bridles or synovial laminæ uniting the diarthrodial surfaces: these bridles are so numerous that they represent a sort of cellulosity; according to their number, length and extensibility, the motions are more or less limited; a thickening and induration of the soft parts, are added to this, the end of all which is, that the parts never perfectly resume their accustomed motion. In true anchylosis, adhesions are not only established between the articulating surfaces, but these surfaces become soldered together, confounded, the continuity is perfect between the bones, whose compact laminæ, as well as whose cartilaginous laminæ which separate them, finally disappear, so that their spongy tissue is confounded; this change begins in the synovial membrane, for this reason we speak of it here. Ulceration is a more rare termination of inflammation in the synovial membranes.

§ 220. In white swellings, among which are included various changes, such as inflammation, dropsy, diseases of the cartilages, &c., is found an alteration peculiar to the synovial membranes: it is a state in which these membranes are converted into a fungous substance, from whence springs a vegetation that extends to the skin, and even penetrate through it. Reima-

rus, Brambilla, and M. Brodie have described these cancerous fungi.

§ 221. Foreign bodies are formed in the articulations: they are most generally seated in the knee. Their size as well as their number and consistence varies, as has been already stated, while speaking of the serous system in general; they are formed outside the synovial membrane, and appear to be the result of a peculiar change of the nutrition. They gradually advance into the interior of the membrane, and are finally detached in the way before mentioned. Their presence, which is accompanied by violent pain, when placed between the articulating surfaces, produces no uneasiness, when in moveable parts, and where the articulation is loose. Depressions more or less deep, are sometimes finally made by their pressure on the cartilages, and as these depressions correspond in form to that of the bodies lodged there, it has been said, that the latter were pieces of cartilage separated by external violence; but to prevent the admission of this opinion, it is sufficient to consider, that in the greater number of cases in which those bodies are found, the depressions do not exist, that they have no resemblance to fractured surfaces, and that the bodies are much thicker than the articular cartilages themselves.

ARTICLE IV.

OF THE SEROUS SPLANCHNIC MEMBRANES.

§ 222. The serous membranes, properly so called, also styled the diaphanous membranes, are those which line the splanchnic cavities, and which furnish tunicks more or less perfect, to the viscera situated therein.

§ 223. These, like all other serous membranes, were for a long time confounded, both in their healthy and diseased conditions, with the organs they envelop, and the parts they invest. With respect to the first, however, each of these membranes had been successively and exactly described, independently of the parts they cover; some anatomists, Monro for in-

stance, had even indicated the analogy that exists between them. As regards their pathology, Sauvages and M. Pinel had already established an order of inflammation for that of the diaphanous membranes, but one comprehending the inflammations of the stomach, of the intestine, bladder, and epiploon, as so many genera. Various pathologico-anatomical observations, those of T. G. Walter on the peritoneum, in particular, had shown that this membrane, like all other serous membranes, could be affected throughout its whole extent, and independently of the subjacent parts; finally, Dr. Carmichael Smith had noted with exactness, the identity of the inflammation of all the diaphanous membranes, when Bichat gave his exact and complete description of the serous membranes, and particularly of the arachnoid. Descriptions of some of these membranes have been given since;* but little, however, has been added to what our celebrated anatomist has said; more has been added to ther pathological history.

§ 224. The serous membranes of which we are now speaking, are situated in the cavities of the trunk, which they line; they there invest the most important organs, those that are the most essential to life. These membranes are distinct and separate from each other; their number is but small; viz. 1st, the peritoneum in the abdomen, where it invests more or less perfectly the greater part of the organs of digestion, that are contained in this cavity, and rather less the genital and urinary organs; 2d and 3d, the two pleuras, and 4th, the pericardium in the chest, where each one of these membranes is restrained to a single organ, and to the parietes of its cavity; 5th, the arachnoid in the cranium, and in the spinal canal; 6th and 7th, in man only, the tunica vaginalis.

The extent of these membranes, collectively, is very considerable, and greatly surpasses that of the skin. The peritoneum is the greatest of these membranes, its extent being equal, at least, to that of all the others together.

§ 225. The general description of the serous membranes,

* *See* Langenbeck. *Commentarium, de structura peritonæci. ect. cum tabulis.* Gotting, 1817.—L. Rolando. *Osservazioni sul peritoneo et sulla pleura in mem. della real Acad. delle scienze.* Tom. xxiv, Turin, 1820

has already in a great measure explained the species of which we are now speaking, and which may be considered as the type of the genus. Their form is the same as that of all the serous membranes, that of a bladder without an opening, and with contiguous parietes. On the one hand, it lines the internal surface of the parietes of the cavity in which they are contained, and on the other, it furnishes tunicks or external envelopes to the organs. The pleura, the pericardium, and tunica vaginalis have a tolerably simple conformation, their parietal and visceral portions, continuing around the point where the organ they invest is attached by vascular prolongations, to the parietes of the cavity that contains it. As to the arachnoid and peritoneum, their disposition is a little more complex, without, however, ceasing to be essentially the same. With respect to the first, the complication is owing to the great number of vessels and nerves that terminate in, or depart from the brain. Now on each of these parts, the arachnoid forms a sheath, which continues to one of its extremities with the visceral lamina of the membrane, and to the other, with its parietal lamina, an arrangement previously pointed out and figured by Bonn, to which Bichat has particularly drawn our attention, and from which it results, on the one hand, that the membranous cavity is not open, and that the parts of the membranes are continuous to one another. As to the peritoneum, its complexity depends upon the great number of parts to which it furnishes coverings, and upon the various disposition of these parts, of which some are very near the posterior wall of the abdomen, whence they receive their vessels, and are simply covered with the peritoneum; others again are removed from it, sometimes greatly so, and are suspended to membranous bridles which contain the vessels in their thickness. Its complexity depends also upon vascular prolongations, projecting beyond the viscera, and to which the serous membrane furnishes epiploical or floating envelopes. This membrane is peculiar also in being the only one that has an opening communicating externally through the fimbriated body, and fallopian tubes. More extensive details on the conformation of the splanchnic serous membranes, belong to the

special anatomy of these membranes, and particularly to that of the peritoneum and arachnoid.

§ 226. Of the two surfaces of these membranes, one is generally free, in a healthy state, and the other adherent. The free surface is shining, moist, and appears polished; it is, however, covered with small villosities which become visible on looking at it under water, and which the inflammatory irritation renders very apparent. It is to the serous membranes which envelop and line them, that the organs and parietes of the splanchnic cavities owe their shining aspect; wherever they are without it, they have not the same appearance. This free surface, every where contiguous to itself, as well as the serosity that humects it, creates a distinctness, a true isolation between parts very nearly approximated; they also singularly facilitate the motions of these parts.

§ 227. The other surface of the serous membranes is almost universally adherent, either to the viscera or the walls of the cavities; there are only some prints of the visceral lamina of the arachnoid, which are free on the two surfaces, every where else the external surface of the serous membranes is adherent. This adhesion is on one side with the parietes of the cavities, and on the other, with the surface of the viscera. The degree or solidity of this adhesion generally varies. In general, wherever the serous membranes are connected with a ligamentous tissue, as with the dura mater, the pericardium, the aponeuroses of the abdominal parietes, the tunica albuginea of the testis, &c. there this adhesion is very intimate; it is also very great with the muscular and other parts, as the heart, lungs, stomach, intestines, &c.; it is much less so, in other places, as where the membrane passes from an organ to the walls of a cavity, and vice versa; where it forms bridles, or floating prolongations that contain vessels; in the places where the sub-serous cellular tissue contains fat, and, generally, whereever it is loose.

§ 228. These differences are of sufficient importance to demand further attention; the consequence is, that when, for example, the uterus, the bladder, the stomach and the intestines augment in volume, the peritoneal bridles and ambiant

folds open, spread out, and are applied to the organs, and then when the latter recede to their original condition, the membrane becomes foreign to them; this is owing to the laxity of the sub-serous cellular tissue, near the adhering edge of these folds. When a hernia is produced in the groin and increases in size, it is chiefly by the displacement, the sliding of the serous membrane, assisted by the laxity of the adhesions, that the sac increases; when, on the contrary, an umbilical hernia augments in volume, it is by thinning and distention, that the sac increases, the adhesion of the peritoneum about the umbilicus being intimate. Bichat has, perhaps, exaggerated a little the influence which the laxity of the adhesions of the serous membranes, may have in limiting their diseases and those of the subjacent parts.

§ 229. The physical properties of these membranes are those of the serous system in general already described: they are thin, but this tenuity is not the same in all, neither is it so in all parts of the same membrane, nor in different individuals. Soft, semi-transparent, &c.; their extensibility is strongly marked, more so than that of the synovial membranes; their strength tolerably great, and much greater than that of the cellular tissue; they are slightly elastic. When these membranes are distended beyond a certain degree, their texture becomes loose; this looseness is on the free surface; the rest of the thickness of the membranes, resists the laceration more strongly, or yields more to the distention.

§ 230. They all consist of one lamina, which is so much the more dense and close, if examined on the free surface, and whose texture is more lax on the opposite side where it becomes flaky and is confounded with the common cellular tissue. Until the period when Douglass gave an exact description of the peritoneum, this membrane as well as those of the same species was considered as bifoliate, and containing the viscera in the space between their separated layers: it was an error which he refuted, and that Vacca and others have vainly tried to revive. The pretended external leaflet is nothing more than the sub-serous cellular tissue, so well described by Douglass. They consist essentially of one layer of extremely close

and condensed cellular tissue, more and more distinct from the cellular tissue, from the adhering surface where it insensibly continues with it, to the free surface where it greatly differs; fibres or little interlaced fasciculi are not so manifest in it as in the synovial membranes. The floating appendages of these membranes contain, also, free cellular tissue, and often fatty tissue; they are much more vascular than the other serous or synovial membranes. They contain an immense quantity of white or serous vessels which become visible by injection, congestion, or inflammation and some very delicate red vessels, which belong to their external surface, and particularly to the sub-serous cellular tissue, as may be proved by detaching the membrane, which is found to be white in those places, where one would have supposed there was a number of red vessels that were in fact only seen through it. The red vessels are particularly abundant in the loose or floating folds. Nerves have been traced to these membranes, but not into their substance.

§ 231. These membranes, when dried, become transparent, elastic and tolerably firm, assuming a light yellowish colour; by immersion in water they resume their original properties. Maceration first renders them soft, opaque and thick, then pulpy, and ends, but after a very long time, by dissolving them. In bodies beginning to be decomposed, these membranes impregnate themselves with liquids on the one hand, and permit them to transude on the other, hence their diversity of colour. Fire and boiling water render them horny. Continued ebullition converts them into gelatine and a little albumen. These different characters approximate them to the cellular and ligamentary tissues.

The force of formation is less developed in them, than in the free cellular tissue. Irritation produces no sensible motions in them, but it changes their secretion and texture; it inflames them. They are sensible in this state only, in which they usually become the seat of violent pain.

§ 232. In a state of life and health they are humected on their contiguous surface by serum they are continually depositing and absorbing. This secretion had been attributed to

certain glands supposed to be lodged in their tissue. Ruysch has proved that these pretended glands do not exist. Hunter thought that this secretion was produced by a true transudation, analogous to the cadaverous transudation through the areolæ, interstices or an organic porosities of the tissue of the vessels. Although the true way and organic mode by which the perspiratory and other secretions are performed, are not well known, we may at least affirm that they differ from transudation, which takes place only in the dead body. The serosity in the healthy state is so small in quantity, as to be scarcely perceptible, and hardly capable of being collected. Hewson collected, from animals suddenly killed, a small quantity of the liquid that humects the serous membranes, and he saw by exposing it to the air and leaving it at rest, that it coagulated like the coagulable lymph of the blood. He was not able to collect the serosity of the cellular tissue. Bostock has found in the healthy serosity of the splanchnic cavities, water, albumen in less proportion than in serum, incoagulable matter and salts. Schwilgue found in it, albumen, an extractive matter, and a fatty matter. From the examination that I have made of the serosity of the splanchnic cavities, it seems to me, that the incoagulable matter is gelatiniform mucus, similar to that found in the coagulated albumen of the serum of the blood. The coagulability of the healthy serosity, observed before Hewson by Lower, Lancisi, and Kaau, has been, on the contrary, denied by Sarcone, Cotunnio and Gerominі;* I believe this coagulability always exists in the healthy state.

§ 233. Of all the serous membranes, those of which we now speak, are those whose functions and morbid actions are the most closely connected with the other organic phenomena, presenting, however, some varieties; thus the membrane of the testicle, and that of the abdomen, differ greatly in this respect.

§ 234. The greater part of what has been said respecting the morbid changes of the whole serous system, may be ap-

* *Saggio sulla genesi, e cura dell' idrope.*—Cremona, 1816.

plied to these. They are subject, more than the other, to some primitive vices of conformation, as unnatural openings, observed in some cases of monstrosity, of which they all may present examples, as well as the prolongations or appendages which envelop congenital hernias and other displacements.

§ 235. Accidental hernias are also accompanied by an alteration in the form of the splanchnic serous membranes; displaced parts are almost universally enveloped by a hernial sac: this sac is formed by the serous membrane which lines their parietes, and which the viscera, in being displaced, push before them.

§ 236. Dropsy, inflammation and its effects, false membranes, adhesions, accidental productions, either analogous, or morbid, are more common in the splanchnic serous membranes, than in the other species, and still more common among some of their own number than in others.

§ 237. Although the splanchnic serous membranes, form a tolerably natural group, they still present differences which belong to special anatomy; the arachnoid besides, differs much from the others. It has the same conformation as the others, but its consistence is soft, its tenuity extreme, and its texture it is impossible to determine; it seems homogeneous; no vessels are to be found in it, not even in a diseased state. The greater part of the morbid phenomena attributed to it, takes place in the subjacent tissue of the pia-mater; it seems, in fact, to form a genus by itself.

CHAPTER III.

OF THE TEGUMENTARY MEMBRANES.

§ 238. These membranes are those which, internally as well as externally, clothe the parts that are exposed to contact with foreign substances. They are also called compound villous, or folliculous membranes, on account of the numerous parts which enter into their texture, and of the follicles which they contain in particular. They constitute, next to the cellular tissue, of which they are a modification, more or less compound, the most universally extended tissue or organ in the animal kingdom; they are the first parts that are distinct and figured in the embryo; it is on them and by them that all the rest of the body is formed; in health during life, they are the organs of the most essential functions; and it is in them and by them that absorption and extensive secretion takes place; it is upon them that all foreign substances produce impressions; they are often changed by disease; it is on them, in fine, that most therapeutic agents are applied: their study then is of the highest importance to the physician.

§ 239. Galen* had already remarked, that besides the external skin, which is the common tegument of all the parts, there is a thin membranóus skin which clothes the internal parts; several anatomists† had already indicated the continuation of the skin into some of the natural cavities, and‡ the analogy of the mucous membrane with the epidermis; Bonn§ had already described in detail, the continuation of the skin with the internal membrane, into all the openings and cavities;

* *Of the therapeutic method*, I. xiv. chap. 2.

† Casserius, *Pentaestheseion, hoc est, de quinque sensibus, liber*.

‡ Glisson. *De Gulâ, ventriculo et intestinis*.

§ *De continuationibus, membranarum*.

zootomists and naturalists had also observed it, as well as the analogy subsisting between these two parts of the same membrane, in the interval of which all the rest of the body is placed. Bichat has particularly insisted upon this continuity. M. J. B. Wilbrand* has recently given an exposition in detail of the cutaneous or tegumentary system in all its divisions. M. Hébréard† has described the transformation of the skin into mucous membrane and *vice versa*.

§ 240. The tegumentary membranes, throughout their whole extent, have common characters, of which it is necessary to speak first, but from their difference of situation, texture and functions, they are divided into two parts, which must, subsequently, be separately described: these parts are, the mucous membrane and the skin.

SECTION I.

OF THE TEGUMENTARY MEMBRANES IN GENERAL.

§ 241. The teguments, however extensive and numerous they may seem, form one single and same membrane, every where continuous to itself from the external skin, to the bottom of the last ramifications of the excretory duct of the most deeply seated gland: this membrane consequently has immense breadth. Its situation is everywhere external or superficial, inasmuch as it is situated on the surfaces of the body whose limits it forms, and as it is every where in contact with substances foreign to the organization; but one portion only is visible externally, and envelopes the whole body, while the other part is hidden, and lines the alimentary canal, which traverses the trunk through its whole length, from the mouth to the anus. We may hence easily conceive the figure of the tegumentary membrane, to be that of an envelope, and of a canal which

* *Das, hautsystem in allen seinen verzwergungen, anatomisch, physiol. und pathol. dargestellt.* Giessen, 1813.

† *Mém. sur l'analogie qui existe entre le systeme muqueux et dermoïde; Mém. de la Soc. med. D'Emul.* vol. viii. p. 153.

traverses it, continuous with each other to the two extremities; or rather as that of two canals, the one wide, the other narrow, the narrow one cased, in the other, and continuous to the two ends, and in the space between which the remainder of the body is lodged. If we wished to employ a trivial comparison, the one which is best fitted to represent this disposition is that of a muff, having in fact two surfaces separated by a layer of intermediate substance, more or less thick.

§ 242. Besides the skin and the mucous membrane of the alimentary canal, continuous with each other to the two orifices of this canal, every where continuous with themselves, and which constitute the two principal parts of the tegumentary membrane, this membrane has a great number of dependencies or prolongations more or less extended and ramified in the thickness of the body: such are, 1st, the genital and urinary membranes, which are prolonged into all the cavities of the organs of generation, and the urinary depuration; 2d, the pulmonary membrane which lines all the divisions of the bronchiæ; 3d, the membranes which line the excretory ducts of the glands, whether they terminate in the mucous membrane, or like those of the mammæ, in the skin; 4th, those of the nasal cavities, of their sinuses, and posterior nasal fossæ, of the auditory canals, of the tympanum, of the mastoid sinus, and of the surface of the eye.

Among these prolongations, all mucous, except that of the external auditory canal, which is cutaneous, the greater portion of them terminate in and are appendages or prolongations of the mucous membrane; the external skin, on the contrary, is much less complicated by appendages of this kind.

§ 243. The tegumentary membrane presents, in its vast extent, differences of appearance, of texture, and of function, which might induce one to doubt of its unity and continuity.

The skin and mucous membrane compared with each other, at the first glance, seem to be very different; but in the animal series, the difference is gradually effaced in the more simple animals; it is also, generally, but slightly marked in the higher animals which inhabit the water. In the human fœtus, the difference, though real, is at first but slightly defined. Even

in the adult we see the skin easily transformed into mucous membrane, and the latter into skin. When, for example, a part of the surface of the body, is for a long time substracted from the action of the atmosphere, as has been seen in cases of contractions, where the leg has been strongly flexed upon the thigh, as is often seen in the furrows of the skin of very fat children, the epidermis softens and disappears, and the skin at last secretes mucus. In a prolapsus of the uretus, on the contrary, we see the mucous membrane of the vagina, and in a prolapsus of the anus, natural or accidental, that of the rectum, thicken, dry and assume the appearance of the skin. Finally, in a healthy state, in many parts, we see the skin change into mucous membrane gradually and insensibly; this is the case in the labia pudendi, the prepuce, anus, mammæ, and nostrils; it is only in the eyelids and lips that the line of demarcation appears somewhat defined. There is then no real interruption, but, on the contrary, there is a perfect identity and continuity between the two principal parts of the tegumentary membrane.

§ 244. The various parts of these two principal portions of the tegument, present also tolerably great differences. Those which are observed between the skin of the back and that of the eyelids, between those of the cranium and of the papillary extremities of the fingers, for instance, are tolerably great, but they are neither absolute nor definite; it is about the same in the mucous membrane, and the interruptions which have been supposed to be found there, are merely apparent, as will be seen hereafter, (*sec.* ii.) The differences that are observed between the various parts of the mucous membrane, although more strongly marked than those which are found in the skin, are not more real. The change of appearance and texture is generally gradual, as is visible in the excretory ducts where the membrane becomes progressively thinned and degraded, if we may so express it, but in an insensible manner. If we compare the membrane of the frontal sinuses, with that of the stomach, we will certainly find great differences between them, as well as between those of the tongue and of the uterus; but these differences are, in a manner, connected by

intermediate gradations. We only find some suddenly marked differences, in parts closely approximated, but whose functions are very different, as between the œsophagus and the stomach, the vagina and the uterus; but even there as well as every where else, they are only varieties, which easily reduce themselves into a unique type of organic texture.

§ 245. The teguments have a free and an adhering surface. The first is turned outwards for the skin, and inwards for the mucous membrane; it is the inverse with the second. The adhering surface corresponds to the mass of the body and to the cellular tissue generally. This tissue [139] forms there a layer more or less dense, more or less thick; in other places it is the ligamentous tissue, or the fibrous elastic tissue which lines the teguments; in a considerable portion of their extent, they are lined with muscular fibres.

§ 246. The tegumentary membrane, besides the great appendages and excretery ducts of the glands of which we have spoken [242], has an innumerable multitude of other depressions, more simple and a great deal smaller, that have been called follicles, loculæ, lacunæ, crypta, simple glands, &c. These follicles,* at first observed and described in some points of the teguments by various anatomists, and afterwards in all the parts by Malpighi, Boerhaave, Kaau, and many others, exist in all or nearly all the parts of these membranes. The follicles are round, or obround, graniform, of a variable size and generally very small: they are situated, in part, in the thickness of the membrane, and project more or less under its adhering surface. They have generally the form of a little ampulla, whose mouth more or less lengthened, opens on the free surface of the membrane. They are formed by a reflected fold of this membrane, constituting a depression or a little cul-de-sac. They constitute the pores that are perceived on the surface of the skin, in the nose particularly, as well as the granulations that line and elevate the mucous

* *See* M. Malpighi, *Epistola de structurâ glandularum, etc. in op. posthum.—Opusculum, anatomicum, de fabrica glandularum, continens, binas epistolas.*—Boerhaave et F. Ruyschii, etc. *in op. omn. Ruyschii.*—A. Kaau. *Perspiratio dicta Hippocrati, etc.* Cap. xi. xii. et xiii.

membrane in many places; the cavity of these follicles is extremely small in comparison with the thickness of its parietes. They are formed by the whole membrane, whether still preserving its thickness, or having it increased or diminished. They are surrounded by an immense number of minute vascular ramifications. The majority of these little ampulla are simple, distinct, and placed more or less apart from each other; but in certain parts of the skin, and of the mucus membranes especially, follicles are found variously assembled and composed. Besides these follicles of which we are speaking, the tegumentary membranes, and chiefly the internal one, presents many depressions, whose orifice is as large as the bottom, and which are called alveolar, and both the one and the other present a great number of little tapering, or infundibuliform depressions. The follicles differ from each other, also, in the nature of the liquid they secrete and contain: those of the skin are called sebaceous follicles, and those of the internal tegument, mucous follicles, so styled on account of the liquid they furnish; those of the mucous membranes in the vicinity of the skin are almost of a mixed nature, participating of both.

§ 247. The teguments have a foliated texture; throughout a great part of their extent they are evidently formed of two layers, the dermis and the epidermis; in many places, another tolerably compound layer is found between the two first; and in a great number of parts, there are, besides, appendages, or productions, arising from the free surface of the membrane.

§ 248. The dermis, whatever differences it presents in the two teguments and in their divisions, is always the deepest part of them, the thickest, that which forms their base, and on the surface of which the others are placed. It is formed of a layer of fibrous cellular tissue, more or less dense, furred, and leaving interstices through which pass various other parts.

§ 249. Blood-vessels, lymphatics and nerves, more or less numerous, are distributed and ramified through the thickness of the dermis and on its superfices, where they form inequalities called papillæ, villosities, vascular buds, and which will be more exactly defined and described, when speaking of each of the two teguments.

§ 250. The surface of the dermis is covered with a layer more or less distinct, according to the part of the tegument, and which is called the mucous or reticulated body; it is cellular tissue, in a semi liquid, or imperfectly organized state, in which the most minute divisions of the white vessels arise or terminate; this layer, otherwise very compound, is the seat of the colour, and that of the horny incrustations which cover the teguments in some places. This layer is less distinct in the mucous membranes than in the skin.

§ 251. Finally, the epidermis is the last essential part of the tegumentary membranes, that which forms their free surface; it is an albuminous layer excreted on the surface of the mucous body. In many parts of the mucous membranes, the epidermis is not distinct and seems to be substituted by mucus. Independently of this, and as regards the chemical nature of the matter, there is much resemblance between the epidermis and mucus.

§ 252. Several parts of the tegumentary membranes, are provided with salient appendages on their free surface: these are, the nails and hairs for the skin; and the teeth, for the mucous membrane.

§ 253. By decoction, the teguments are resolved almost entirely into gelatine. The very different colours of the teguments depend partly upon that of the blood and partly upon a colouring matter secreted from it, in the mucous body. Their very variable density, is nearly intermediate between that of the cellular, ligamentous, and elastic tissues. Their elasticity is tolerably well marked. They possess, also, a very great, but slow extensibility and retractability. Their formative power is highly developed. Although their irritability is much less evident than that of the muscles, they possess a large share of it. They are the essential organ of sensibility.

§ 254. The organic action or function of the tegumentary membrane is very important, very complex and different in the different parts of that membrane. As a tegument or envelope of the mass of the body, internal as well as external, it constitutes a barrier through which must pass inwardly

from without, all the foreign substances that enter into the body to become portions of it, and from within outwardly, all those which after having been parts of it, become foreign to it; these substances and all others which are in contact with the tegument, determine impressions on it; thus this membrane is an organ of defence or protection of more or less efficacy, against the action of external bodies; it is the organ of external absorptions and secretions, *i. e.* of those, the matter of which is taken from, or deposited without; it is the organ of all external sensations, and of the feeling of want and appetite; and, finally, through its appendages, it is sometimes an organ of offence or aggression. But the functions of this membrane vary in the different regions, according to the nature of its texture; thus the mucous membrane is better fitted for absorption and secretion than the skin, while the latter is more adapted to receive sensations and defend the body than the former. Some parts are specially fitted for sensation, and even for this or that sensation, others for absorption, some for excretion, others for generation, respiration, &c.

§ 255. The immense extent of the tegumentary membrane, the number and importance of the functions of which it is the seat and instrument, render its consideration a matter of much importance, both in health and disease. Between the two principal parts of which it is composed, there exists the most intimate relation, which in certain respects, was perceived by the most ancient observers,* who knew that the abundance of the mucous secretion is generally in an inverse ratio to that of the cutaneous secretion. Observation has taught us that a healthy state of the skin coincides with a similar condition of the mucous membrane, and that, for instance, those persons whose skins are very white, and of a fine delicate texture, are very liable to diseases of the skin and mucous membrane, and particularly to discharges from these two membranes. It has also taught us that every part of the skin sympathizes with the whole mucous membrane, and with this or that part of it especially. There also exists an equally intimate relation be-

* Ηδερματος ἀραιοτης ἡ κοιλιης πυκνοτης. ΙΠΠΟΚΡΑΤΟΥΣ, των 'πιδεμ. Βιϐλ. ϛ.

tween the teguments and the mass of the body, and *vice versa;* a relation which is daily rendered obvious by observation, one which morbid causes are continually putting in action, from the observation of whose symptoms the practitioner endeavours to profit.

§ 256. We have already stated that the embryo is wholly formed on these membranes: the vitellar or intestinal membrane is the first that appears in the egg; it is by its prolongation towards the stomach, and towards the anus that the intestine is formed. The second apparent part is the allantoid or the vesical membrane, by the extension of which the urinary passages and genital organs are formed. The external skin is next produced: at first widely open in front of the trunk, it closes in the median line of the abdomen, and finally, round the umbilicus. In the two sexes there is a great difference of conformation in the genito-urinary portion of the teguments, and a difference of development in that of the excretory ducts of the mammæ. Besides this, there is a difference of colouring and of thickness in the external skin. These differences are well marked in the various races of the human species, and are also visible in individuals.

§ 257. Morbid changes are very numerous in the different parts of the tegumentary membrane. Accidental, cutaneous, and mucous productions frequently occur. Reproductions of the tegument or cicatrices, are seen daily. Vices of conformation, alterations of texture and functions, accidental productions, analogous or not to the healthy tissue, transformations of tissue, &c. are also frequently observable in the teguments; but their description will be better placed after that of each of these membranes; the same observation will apply to their cadaverous alterations.

§ 258. The accidental teguments, on the contrary, should be described here, because, on the one hand, their production is very analogous in both teguments; and on the other, because in the production of an external cicatrix, the new tissue, during one period of its formation, resembles the mucous membrane, and at a later one, the skin; and finally, because in some cases we find the appearance and texture of the skin in one part, and

that of the mucous membrane in another of the same production. Such as, for instance, the membranes of fistulas.

Every time that either by mechanical lesion, by the effects of cauterization, gangrene, or ulceration, there is a destruction of the teguments, or even of the subjacent parts to a greater or less depth, a tegument is always produced similar to the one destroyed, or at least very analogous to it, and similar in its whole extent, whatever be the diversity of denuded parts that are to be reclothed by it. After the primitive phenomena, varying according to the causes of the injury, there is a series of secondary ones always similar: they are 1st, the production of a plastic layer like that of agglutination; 2d, the formation of buds or granulations, and the secretion of pus; 3d, the cessation of this secretion, and the completion of the cicatrix. The phenomena of cicatrization commence by the deposition of a plastic layer similar to that which constitutes the false membranes. This layer at first is inorganic, but soon becomes organized, covered with little red, conical granulations, and constituting then the membrane of the fleshy granulations; this membrane is cellular, vascular, very contractile, sensible, absorbent, secreting pus, apt to be destroyed by ulceration, and quickly reproduced. This membrane is continually contracting, the secretion of pus gradually diminishes, and finally ceases, when it becomes covered, either with a distinct epidermis, or with mucus, according to the part, and constitutes a new tegument, very analogous, and sometimes absolutely similar to the old one. This membrane, however, besides some slight anatomical differences, is much more susceptible of ulceration than the primitive teguments.

§ 259. In abscesses, and particularly in chronic abscesses, a membrane is formed which circumscribes the pus, and which strongly resembles the mucous membrane; this resemblance is still greater, when the abscess is opened and remains the source of a fistulous ulcer; it is the same with that kind of ulcers kept up by necrosis, or the presence of foreign bodies; it is also the same with true fistulas, or the accidental canals which arise from a natural mucous cavity. In every case, the passage is lined through its whole extent by a fungous, soft,

mucous membrane, discovered by Hunter, in fistula in ano. At its orifice in the skin, if it terminates on that surface, the mucous canal of the fistula, to a certain depth, has a distinct epidermis, which is continued with that of the skin.

SECTION II.

OF THE MUCOUS MEMBRANE.

§ 260. The internal tegumentary, or mucous membrane has received the latter name, at first in the nasal fossæ (μύξα, *nostrils*) on account of the mucus (μύξα *pituita*) it produces. It constitutes a humid tegument that clothes all the cavities communicating externally, all of which receive or eject foreign substances. Regarded at first as the particular internal membrane of each hollow organ, and having no other name, afterwards called, villous or fungous, pulpy, porous villoso-papillary, in the alimentary canal, pituitary, or mucus in the nose and throat, anatomists were not long in discovering follicles in nearly all its parts, which caused it to receive the generic appellation of glandular, and in remarking the resemblance of the nasal and intestinal mucus, to the unctuous humour of the trachea and bronchiæ, and even the analogy of mucus to the epidermis; from this moment the identity of the various parts of this membrane was known. Pathologists, M. Pinel in particular, had already remarked this in treating of catarrh. No general and satisfactory description of this membrane, however, had been given until that of Bichat.* Anatomists and pathologists, have since generally agreed in adopting his ideas on this subject, Gordon excepted, who finds too many essential differences between the various mucous membranes, to include them in one common description.

§ 261. The mucous membrane forms an internal tegument to all the cavities that open externally; its more important portion clothes the whole alimentary canal from the mouth to the

* *Traité des membranes.* Paris, an. viii.

anus; the remainder constitutes prolongations or appendages prolonged in a cul-de-sac, more or less extended and ramified in the mass of the body, and their orifice terminating either on the external or internal skin. It thus forms an immense internal tegument, of much greater extent than the skin.

§ 262. The mucous membrane, like the skin, presents an adhering and a free surface; the adhering or external surface is generally covered with a particular layer of fibrous cellular tissue, which has been named by Ruysch and other anatomists, the nervous membrane, which Albinus and Haller have demonstrated to consist of cellular tissue, and which Bichat has called the sub-mucous cellular tissue. This tissue is close, fibrous, white, never contains fat, and rarely any infiltrated serosity; it is traversed by a great number of small branches of vessels and nerves. Several anatomists have assimilated it to the dermis of the skin. However this may be, it is to it, that the hollow organs in a great measure owe their solidity. The mucous membrane is moreover lined throughout the extent of its principal canal and of several of its divisions, by a muscular plane, a kind of internal muscular coat analogous to those muscles we have denominated sub-cutaneous; in some places it is an elastic tissue that covers the mucous membranes, visible in the trachea and the excretory ducts; in others, a true ligamentous tissue, as the periosteum of the nasal fossæ, of the sinuses, of the palate, of the alveolar processes, lines this membrane, making of it a fibro-mucous membrane.

§ 263. The free surface of the mucous membrane presents valvuli, folds and wrinkles, formed by the doubling of the whole thickness of the membrane. The valvuli are formed by folds of the mucous membrane, by the sub-mucous tissue, and by muscular fibres contained in the fold; this is the case in the pylorus, the mouth of the jejunum, in the colon, the velum palati, the orifice of the larynx, &c. The folds contain, in their thickness, sub-mucous tissue only, but they always remain, like the valvuli, and are never effaced: such are the numerous folds of the small intestine which are called valvuli conniventes; the wrinkles on the contrary are accidental or

momentary folds, in which the mucous membrane is in reserve for future dilatations of the organs, or, which depend upon the expansion and subsequent contraction of the organ, by which the mucous membrane is made to exceed the muscular membrane: such are the longitudinal wrinkles of the œsophagus and trachea, the irregular wrinkles of the stomach when contracted, the regular wrinkles of the vagina and of the neck of the uterus, &c.

§ 264. The free surface of the mucous membrane presents also cavities or depressions of various kinds, and papillary and villous projections. But these various objects, although generally dispersed throughout the membrane, do not exist, or at least are not equally apparent in all points of its extent. Infundibuliform cellular or alveolar depressions are found on the surface of the membrane: they are found at the maximum of their development in the second stomach of the ruminantia, which on this account is called the honeycomb; they exist also, but much smaller and more microscopical, in a great part of the alimentary canal, and particularly in the œsophagus, stomach, and the colon of man, where they were perceived and pointed out by Fordyce and Hewson, and described and figured by M. Ed. Home.

§ 265. The follicles* only differ from these alveolar depressions in having a very small orifice, a neck more or less prolonged, and a bottom resembling an ampulla, placed in the sub-mucous tissue where they project. They are formed by a reflection of the membrane, strengthened externally by dense cellular tissue, and provided with numerous small vessels. They are every where to be found, their number, how ever, varies according to the part; they are, in general, very small, but they vary also greatly in size. Some are simple and separate; others terminate in a common canal of which they are as it were branches; others again end in a common and dilated orifice, called a lacuna; such is the hole at the base of the tongue, the lacunæ of the urethra, rectum, &c.; another

* Peyer. *de Glandulis intestinalium.* Amstel. 1681.—T. C. Brunner. *de Glandulis duodeni.* Francof. 1715.

set are aggregated, as the caruncula lachrymalis, the arytenoid gland, the aggregated glands of the ilium, &c.; finally, others are compound and have multiplied lacunæ or ramified ducts, and greatly resemble glands: such are the tonsils, the molar glands, the prostate, the glands of Cowper, &c.

§ 266. The little eminences called papillæ or villosities that are seen on the free surface of the mucous membrane appear to be designed, like the depressions of which we have been speaking and to which, in number, they are in an inverse ratio, to increase the surface; but, in the one as well as the other of these dispositions, the texture and functions of the membrane are remarkably modified. These eminences, called villosities, in consequence of the comparison drawn by Fallopius between the internal membrane of the intestines and velvet, and named papillæ, on account of their supposed resemblance to a button or nipple, do not essentially differ with each other; both are projections of the membrane more or less fine, and the greater part hardly visible to the naked eye.

The most voluminous of these elevations are called papillæ, such are those that fill the cavity of the teeth, commonly called their pulp; those smaller ones that bristle the two anterior thirds of the tongue, and those, still smaller, that are perceived on the gland of the penis, of the clitoris, &c. These elevations belong to the corium of the mucous membrane, furnished in these places with a great number of nervous threads and small branches of blood-vessels, among which the little veins present an erectile disposition. In parts provided with papillæ, the mucous membrane is furnished with a distinct epidermis, called epithelium, on account of its covering the papillæ.

§ 267. The villosities, whose existence is very general, but which are nowhere more numerous, larger, or more apparent, than in the pyloric half of the stomach, the small intestine, and in the beginning of it in particular, are still smaller than the papillæ.

These villosities, which may with justice be styled the *radicles of animals*, are little foliaceous prolongations of the internal membrane of the digestive canal, whose form and length vary

in the different parts of it, and which, the difference of volume excepted, may be compared to the transverse folds or the valvuli conniventes of the intestines. The villi* perceived by Fallopius and Azelli, described and represented by Helvetius, Lieberkühn, Hedwig, Rudolph, Meckel, Buerger and several other anatomists, are found, particularly, in the small intestine; they are not so long and are less numerous in the stomach and colon. To have a fair view of them, it is necessary to take a portion of the intestine unchanged by putrefaction, to open it carefully, to moisten it with drops of water until the surface is completely covered by it, and then to examine it through a lens, which will increase its diameter about forty times.

§ 268. To make this examination as well as others analogous to it, I have used, with much advantage, a little apparatus composed of a glass sphere of small diameter, open on one fourth of its surface, and of an operculum a little smaller than the opening, and of a thin layer of wax. The part to be examined is to be fixed on the wax with small pins, it is then plunged into water with the open sphere, which is to be filled with that liquid, and afterward, placed on the operculum. The apparatus is now withdrawn, and the object to be examined is thus covered by a little lenticular mass of water, which augments its diameter.

§ 269. Examined in either of these two ways, the villi appears neither conical, cylindrical, canaliform, nor enlarged at the summit, as many authors have described them, but rather in the form of little leaves or laminulæ, whose numbers are so great as to convey the appearance of a luxuriant grass-plot. These little leaves, variously bent and consequently seen in various aspects, appear to have different forms: neither are they everywhere the same: those of the pyloric half of the

* *See* among other authors, Helvetius. *Mem. de l'Academie des Sciences.* Paris, 1721.—T. N. Lieberkühn. *de Fabr. et act. Villos. Intest. hom.* Lugd. Bat. 1744, 4to.—R. A. Hedwig. *Disquis. Ampull.*—Lieberkuhnii. *physico-micros.* Lips. 1794, 4to.—C. A. Rudolphi. *in Reils Archiv. der physiol. IV. et Anat. physiol. abhandl.* Berol. 1802.—J. F. Meckel *in Deutches Archiv. fur die physiol. III.*—H. Buerger. *Examen. micros. Villos. intestin. cum iconibus.* Halæ, 1819—8vo.

stomach and of the duodenum, broader than they are long, constitute little blades; those of the jejunum, long and narrow, are better entitled to the name of villi, and near the end of the ilium, as well as in the colon, where they scarcely project at all, they again become laminæ. The villi are semi-diaphanous, their surface is smoo'ʰ, and we can neither perceive on their surface the openings which have been admitted without ever being able to agree as to their number, nor in their thickness, the cellular ampullæ, nor vascular texture that has been described; we only perceive in their gelatiniform substance, microscopic globules arranged in a linear series, and at their base, small branches of blood-vessels and lymphatics of an excessive tenuity.

§ 270. The anatomical texture and composition of the mucous membrane present many varieties or differences, in different parts. The foliated disposition can not be demonstrated in all parts of the membrane, and, on the contrary, manifestly exists in some points of it.

In the greater part of its extent the membrane consists solely in one spongy tissue, more or less soft and very variable as to thickness. With respect to this we must observe, that in the very young fœtus, and in the inferior animals of the series, the external skin itself presents this character of simplicity. As to the thickness, it diminishes successively from the gums, palate, nasal fossæ, stomach, intestines, biliary and urinary bladders, to the sinuses and divisions of the excretory ducts, where its tenuity becomes extreme. It is in this essential part of the membrane and at its surface, that the last divisions of the vessels ramify; it is from its free surface that arise the villosities.

§ 171. But slight traces of a distinct layer of the mucous body is to be found in it, unless we regard as such, the layer of coagulable fluid, that separates the papillæ of the tongue from the epidermis, or consider the gelatiniform surface of the villosities as belonging to it, or admit as proofs of its existence the ephelides or variously coloured spots that are sometimes found in the teguments of the glans penis and of the vulva, as well as the accidental imperfect horny productions,

which are still more frequently observed in the same parts in a form called warts.

The existence of the epidermis is much more manifest, without, however, being general.

§ 272. The epidermis or epithelium is very apparent at the orifices of the mucous cavities; it is less so in their deeper parts, and finally ceases to be apparent. Does it however exist there? Haller and others have thought that it does, and that the accidental membraniform excretions are a proof of it. Every pathologist of the present day, knows that such excretions are generally the result of a plastic inflammation, and sometimes of eschars. The same conclusion has been attempted to be drawn from the formation of an artificial anus, accompanied with a retroversion of the intestine in which the epidermis becomes very apparent; but this only proves that the free surface of the mucous membrane is covered with a substance which is very analogous to the epidermis, and which is very much disposed to undergo this transformation. By depending upon what observation teaches, and, by the use of dissection, decoction and putrefaction, to separate the epithelium, it is found very distinct as far as into the esophagus, terminating suddenly at the union of this canal with the stomach; it is also very distinct in the vagina, terminating all at once on the lips of the os uteri, interruptions long ago known, and erroneously adduced by some modern writers as proofs of the interruption of the mucous membrane itself. In other parts, as in the nasal fossæ and the inferior extremity of the alimetary canal, their diminution of the appearance of the epithelium is gradual, insensible, and it is impossible to assign its limits with exactness. In those places where it is distinct, it dips, becoming thinner and thinner, into the follicles, where it is lost. In places deprived of a distinct epithelium, the free surface of the membrane is covered with a mucous varnish, which from the time of Vesalius and even of Rhazés, has been compared to the covering or tinning of vessels; and of which Glissen has remarked, at least with regard to its functions, the analogy with the epidermis.

§ 273. The cellular tissue which forms the corium of the

mucous membrane, has not a regularly æreolar disposition like that of the cutaneous dermis; it is rather spongy or fungous. Blood-vessels and lymphatics abound in it. Its nerves generally arise from the great sympathetic and the par-vagum: at all the natural orifices, the mucous membrane is supplied with nerves from the medulla spinalis.

§ 274. The colour of the mucous membrane varies from white to red, and besides the intermediate shades, it presents other differences of colour. This colour is owing, at least in a great measure, to the blood which circulates through its thickness, for asphyxia or syncope, either imparts a brown tint to, or instantly deprives of all colour, the parts of this membrane which from their situation are visible. Its consistence is, in general, soft and fungous-like. It varies greatly in thickness, and its tenacity is moderate. The mucous membrane is quickly changed by putrefaction, and the sub-mucous tissue still more so, for it is then very easily detached. Whether it is susceptible of being converted into leather by the action of tanning, is not known.

§ 275. Its force of formation is highly developed; when destroyed, it is soon reproduced with all the characteristics of the natural tissue. It is slightly irritable and possesses a higher degree of tonic contractility than the cellular tissue. Its sensibility is vague and obscure throughout the greater part of its extent. Even when inflamed it does not, generally, occasion much pain. It is very sensible at the natural openings; and at the entrance of the alimentary and perspiratory canals, it is the seat of a special sensibility.

§ 276. Its organic actions or functions are:

1st. Absorption, which is very active and general, and of which the villi are the most active, but not the only, agents.

2d. Secretion, which is perspiratory and follicular, and whose products, differing according to the parts, are all, however, known by the name of mucosities.

3d. Movements of tonic contraction, strengthened in many places by the action of the elastic tissue and even by that of the muscular fibres, with which, in many parts, this membrane is surrounded.

4. Sensations, more or less distinct or obscure, general or special, and feelings of want, or of appetites.

§ 277. The mucosities or the mucous humours that are found on the surface of the internal tegument, are for the most part composed of mucus. Animal mucus* very analogous to vegetable mucilage, but containing nitrogen in addition, is one of the immediate principles of animals. It is found both internally, in the product of the mucous secretion, and externally in the epidermis, hairs and horny parts, of which it forms a considerable portion. In a pure and liquid state, it is white, viscid, transparent, inodorous, and insipid; it contains nine-tenths of its weight of water; it is insoluble in alcohol, soluble in acids, not coagulable like albumen, and not congelable like gelatine; it is precipitated by the acetate of lead; in a dry state it is semi-transparent, fragile, insoluble in water, soluble with difficulty in acids.

M. Berzélius has proved the identity of the mucus of the nose and trachea, and found it composed as follows: water, 933.9; mucous matter, 53.3; hydrochlorate of potash and soda, 5.6; lactate of soda and animal matter, 3.0; soda, 0.9; phosphate of soda, albumen and animal matter, 3.3.

In the analysis of the other mucosities given by this savant, and in those of Messrs. Fourcroy and Vauquelin, there are considerable differences, some of which depend on the difference of parts whence the mucosity was taken, and where it had been mixed with various matters, and others on the difference of the individuals affected with different diseases. In fact, although mucus is always identical, mucosity is neither always nor everywhere the same; generally it coagulates milk.

§ 278. The functions of the mucous membrane are very closely connected with those of the other parts. In a healthy state, the nervous action, the circulation, the functions of the skin, &c. have a manifest influence on the functions of the mucous membrane, and vice versa. In a state of disease, the mucous membrane produces very remarkable sympathetic effects, and experiences also those produced by other parts.

* *See.* Fourcroy and Vauquelin, *Annales du Mus. d'hist. nat.* vol. xii.—Bostock, *Medico-Chir. Transact.* vol. iv.—Berzélius, *ibid* vol. iii.

§ 279. The origin of the mucous membrane, from the very beginning of the egg and its development in the embryo, have been already pointed out. (256.) There yet remains undescribed the formation of the villosities; it is to M. Fr. Meckel that we are indebted for our knowledge of this point of embryogeny. The villosities are formed at a very early period. From the beginning of the third month, they are visible in the form of closely-joined, longitudinal plaits. These plaits afterwards present, on their free edge, notches like the teeth of a saw, which successively augment in depth; and towards the end of the fourth month, the plaits are replaced by that multitude of little eminences which constitute the villosities. They are at first tolerably large and very distinct till the seventh month. In the commencement they are as numerous, although shorter, in the large intestine, as in the small one. Those of the large intestine afterwards diminish in number till birth. We should observe that in reptiles, these villosities are replaced by little longitudinal folds.

§ 280. The differences of the mucous membrane, as regards the sexes, races, and individuals, are not such as can be generally described, excepting always the difference of conformation in the genital and urinary organs of the two sexes. The mucous membrane of the digestive canal, is thicker in the human species than in the mammiferous carnivora, but thinner than in the herbivora; the peritoneal covering of the intestine, on the contrary, is thinner in the herbivora, and thicker in the carnivora than in man.

§ 281. The teeth, as has been already stated, are appendages of the mucous membrane of the mouth, prolonged into the alveoli, as far as the papilla or dental pulp, appendages which may be compared to the hairy appendages and horns of the external skin.

§ 282. The mucous membrane is subject to extremely varied and numerous morbid alterations: it participates in the primitive and acquired vices of conformation, of the organs of which it is a part, as well as of their displacements. It alone also undergoes displacements, more or less extensive, through the loosened texture of the sub-mucous tissue, particularly in the

œsophagus, intestine, and bladder, constituting a false diverticulum. The mucous membrane also presents other prolongations, depending on its elongation and the laxity of the sub-mucous tissue; such are certain prolongations of the plaits or valvuli conniventes, of the uvula, prolapsus ani, of the vagina, &c. Particular polypi, also appears to be a mere vegetation, or hypertrophy of the membrane and sub-mucous tissue; but generally there is an accidental tissue produced. Tumours of the eye-lids, of the amygdalæ, and of the uvulæ vesicæ, should be regarded as a hypertrophy of this membrane and its follicles.

§ 283. The mucous membrane is very subject to a serous and mucous discharge, which constitutes the phlegmorrhagies and blennorrheæ without inflammation. The sub-mucous tissue itself, although rarely, is subject to an œdema or serous infiltration. This membrane is frequently the seat of hemorrhage or bloody discharges; the sub-mucous tissue is also sometimes in a state of ecchymosis. It is also certain that it is the seat of a gaseous evolution or secretion.

§ 284. Inflammation is very common in it, under all its forms. Its anatomical characters, are increased redness, sometimes verging to a brown; a degree of thickening, generally slight, but variable, and proportioned to the duration of the disease; a softening more or less marked; and sometimes an enormous augmentation of the villosities. The most usual result of this inflammation, is an augmentation of the quantity of the mucus, and of a change in its qualities. This catarrhal inflammation often degenerates into phlegmorrhea or blennorrhea. Suppurative inflammation also frequently occurs in it; the membrane without being ulcerated secretes mucus and pus, or even pure pus alone. Abscesses are also sometimes found in the sub-mucous cellular tissue. The plastic inflammation is less frequent. It is, however, frequently observed in the trachea and bronchiæ, where it constitutes croup, and not unfrequently in the alimentary canal, the intestines, bladder, urethra, and sometimes even in the eyes. The organizable matter is usually excreted in pieces, or membranes, of sufficient size and consistence to have been taken for the internal

membrane of the stomach, or of the bladder, &c.; or the patient dies before its organization; at other times, on the contrary, the new membrane becomes organized, and united to the surface of the old one, or it contracts adhesions with itself, and thus forms mucous bridles in greater or less number, which traverse and contract more or less the cavity they occupy.

The inflammation of the mucous membrane is not always erythematous, and uniformly extended over its surface; it sometimes assumes the form of red isolated patches, and often that of exanthematous buttons, whether the little elevations be separate or confluent. It is known that this may be sometimes, but not always, seen upon the mucous membrane of the digestive and respiratory canals, of individuals who have died of small-pox, and that it has in that case been regarded as an internal variola.* This internal exanthema, which appears to consist in an inflammation confined to the follicles, has been particularly observed by Mr. Bretonneau in an epidemic enteritis, whose description, it is to be regretted, he has not yet published.

§ 286. Gangrene, sometimes, and ulceration, frequently, take place in the mucous membrane, particularly after the exanthema of which we have been speaking. After either of these causes of destruction if the individual survives, a new membrane is soon formed in the destroyed places, having all the characters of the old one. We have already said, that the membranes of abscesses, those of chronic abscesses particularly, and above all that of fistulas in the neighbourhood of the anus, as well as that of the fleshy buds, is a mucous membrane, like that of fistulas. The serous and synovial membranes which suppurate, assume the same character. When, on the contrary, a mucous cavity becomes the seat of dropsy, the membrane assumes the aspect of the serous membranes: this is seen to happen in the fallopian tubes, the maxillary sinuses, and less completely in the gall bladder, and the duct of the sub-maxillary gland. Certain cysts, also, by their texture and

* *See* Wrisberg. *in sylloge Comment.* p. 52,—G. Blane *in Transact. for the improvement of med. and chirur. knowl.* vol. iii. p. 423—428.

humours, belong to the mucous membrane: such in particular are the atheroma; but as will be seen hereafter, the atheroma are often follicles of the skin, and in that case it is a slight transformation only.

§ 287. The mucous membrane is subject to various sorts of accidental productions, either healthy or morbid. Sometimes the natural mucous membrane of the vagina, during a prolapsus, that of the prepuce in phymosis, that of fistulas, and particularly in the lungs, become more or less perfectly cartilaginous, and sometimes even bony, either by transformation, or by a new production. Serous cysts have sometimes been observed both in its thickness and beneath it. Accidental hairs are sometimes found on the surface of this same membrane. Imperfect horny productions are likewise found in it. Although fatty tumours are rare in the sub-mucous tissue, they have been found in it: erectile productions in this same sub-mucous tissue are observable, frequently about the anus, and sometimes in other parts of the intestinal canal. Finally, morbid productions are frequently remarked there.

§ 288. The cadaverous changes of the mucous membrane, have been already partly indicated 274. This membrane, soon after death, becomes coloured by the infiltration of the humours that cover it. Thus in the intestine opposite the nates, it is yellowish; it presents livid marks, corresponding to the larger sub-mucous veins, and becomes greenish in the gall bladder, &c.

In certain kinds of death, and in some internal parts, it is the seat of sanguineous, or sero-sanguineous congestions. In death from apoplexy, hydrothorax, and particularly from strangulation, in a word, in all those cases where there is a difficulty of breathing previous to death, it frequently happens that the congestion, after having been at first confined to the sub-mucous veins, and then to the vessels of the membrane itself, finally proceeds to hemorrhage in the stomach and intestines, as Boerhaave and Morgagni had already stated, as M. Yelloly has observed,* and as I myself have several times seen, after

* *Medico-chirurg. Transact.* vol. iv. p. 371.

this kind of death, both in men and animals This congestion is easily distinguished from inflammation by the absence of all morbid, mucous, purulent or plastic product on the surface of the membrane, by the other cadaverous phenomena depending on the settling of the blood in the right side of the heart, and especially by the state of the skin, which, like the mucous membrane, presents livid spots and sometimes echymoses.

SECTION III.

OF THE SKIN.

§ 289. The skin, *pellis, cutis, corium*, δερμα, constitutes the external tegument; it is a compound membrane furnished with various appendages, which envelops and protects the body, and has other important functions.

§ 290. Galen has made some remarks upon the structure of the skin, and particularly upon its functions. The anonymous author of the Anatomical Introduction, and after him, Avicenna, were the first who spoke of the fleshy panicle, panniculus carnosus. Vesalius and Columbus still thought the skin was perforated by the natural openings: but Casserius, as we have already seen, had observed that it was continued into the nostrils and mouth; we are also indebted to him for a figure of the epidermis, separated from the dermis. J. Fabricius has given a very exact and detailed account of the various appendages of the skin of animals; since then, the observations of anatomists upon this organ, have been greatly increased.*

* M. Malpighi, *de linguâ exercit. epist.—de Externo tactu organo epist.*, *in op. omn.* tom ii.—J. M. Hoffmann, *de cuticula et cute.* Altd. 1685.—Littre, *Obs. sur les differentes parties de la peau, etc.* Acad. roy. des Sci. 1702.—F. de Riet, *de Organo tactûs.* Lugd-Bat. 1743.—J Fantoni, *de Corporis integumentis, etc.* Turin, 1746.—Lecat. *Traité des sens.*—Cruikshank, *Experiments on the insensible perspiration, etc.* Lond. 1795.—C. F. Wolff, *de Cute, in nov. Com. Petrop.* vol. viii.—G. A. Gautier, *Recherches sur l'organe cutané.* Paris, 1811.—Dutrochet, *Obs. sur la struct. de la peau.* Journ. compl. vol. v.—J. F. Schroter, *das Menschlich Gefühl, etc.* Leipzig, 1814.—Lawrence *in Rees' Cyclopædia.*—Seiler *in Anat. physiol. Realworterbuch.*

ARTICLE I.

OF THE SKIN IN GENERAL.

§ 291. This membrane, extended over the whole surface of the body, whose figure in many of the inferior animals it determines, and receiving on the contrary the form of man and the other vertebrata, is in fact moulded on the subjacent organs, permitting their more strongly marked projections to be seen. Everywhere continuous to itself, an apparent interruption is only to be found in various places on the median line, called the raphe, and which indicates it to have consisted originally of two separate halves. This raphe is well marked in those places where the two halves unite last, and where anormal divisions are most usually found, as in the upper lip, in the perineum and below the umbilicus. The skin seems perforated, but is not, at the apertures of the digestive canal, and the orifices of the respiratory, urinary and genital organs, places where it is reflected and continues on, changing its character with the internal skin. It is the same at the meatus auditorius externus, where it sends a cutaneous prolongation to the eyes and the ducts of the mammæ, into which it transmits others of a mucous nature.

§ 292. The skin presents two surfaces. The free surface, which is external and in contact with the atmosphere, presents various objects for consideration: we there see wrinkles or folds more or less deep, some of which depend on the subcutaneous muscles situated on the head, neck, and about the anus, where the skin can not accompany their contraction; it is the same with respect to the wrinkles on the scrotum occasioned by the contraction of the subjacent tissue; others answer to the articulations and are caused by their motions: such are those of the hands, feet, &c.; others again depend upon emaciation and muscular atrophy, when these phenomena are rapidly produced and at a sufficiently advanced period of life for the skin to have lost its contractility. The surface of the skin presents, besides, small wrinkles, in the palm of the hand and sole of the foot, that are peculiar to the epider-

mis; they are salient lines separated by depressed ones, variously directly and formed, and which are made by series of papillæ. On the back of the hand, and on the forehead they are polygons; on the cheeks and breast, mere points and rudiments of stars, &c. We also find on the free surface of the skin, small round openings that are every where distributed, and particularly abundant in the face: they are the orifices of the sebaceous follicles. There are others still smaller, microscopic openings or apparent pores of the epidermis, but in reality, infundibuliform depressions, terminating in a cul-de-sac. This surface is in general tolerably smooth; it is slightly moistened by the transpiratory fluid and the sebaceous matter.

§ 293. The deep or adhering surface of the skin is connected, in general, with the subjacent parts by loose cellular tissue, which permits a mutual sliding between the skin and the parts it invests. Sub-cutaneous bursæ mucosæ, in some places, interrupt the continuity of the cellular tissue, and greatly increase the motility of the skin and parts beneath. In other places, on the contrary, the cellular tissue is dense, firm and scarcely distinguishable from the skin: it is so on the head, back of the neck, back, and abdomen. In others again, it is by fibrous or ligamentous tissue that the skin adheres to parts beneath; this is the case at the wrist, instep, palm of the hands, sole of the foot, and particularly under the heel. Adhesion is effected in some places by means of a reddish, cellular, semi-muscular tissue, if I may be allowed so to call it; such is the dartos in the scrotum and the labia pudendi. Finally, in some places it is the muscles that line the skin attached to them; such are the sub-cutaneous muscles of the cranium, of the face, of the neck and of the hand. The fleshy panicle of the mammiferous animals, more highly developed than that of man, in the face excepted, is analogous to the sub-cutaneous muscles of the latter. The anatomists of the middle ages have strongly doubted or denied its existence in man; that it does exist, is evident, but its extent is but small. In many places the sub-cutaneous cellular tissue is mixed with adipose tissue, and these two penetrate into the

thickness of the skin together. The sub-cutaneous cellular tissue is traversed by large veins, by numerous arteries, lymphatics and nerves.

§ 294. The cutaneous or sebaceous follicles* bear the strongest resemblance to the mucous follicles.

They exist throughout the whole extent of the skin, at least it is so admitted, the palm of the hand and sole of the foot excepted. Their existence is conceded, because the whole surface of the skin is covered with the sebaceous humour; because by careful dissection, aided by a lens, they are discovered in places where they are excessively slender; and because certain morbid changes render them evident in places where they are not otherwise perceptible. They are particularly abundant where there are hairs, in the vicinity of orifices and in the folds of the groin and axilla. They are placed in the thickness of the skin or beneath it; an excellent view of them may be attained by cutting through the skin obliquely. Their orifices form tolerably distinct pores on the surface. They are about the size of a grain of millet, or even smaller; they vary in size; those of the nose are tolerably large, in the cheeks they are much smaller. Their figure is that of a little ampulla. They are generally simple and separate; those of the nose, however, are very closely approximated; some of them are confluent, or compound. They consist in a little ampulla formed by the skin, thinned, reflected, and furnished with numerous vascular ramusculi. They contain an oleo-albuminous matter that differs a little in the various regions of the body.

§ 295. The anatomical texture and composition of the skin, are delicate points of anatomy, that have greatly exercised the patience of observers, and upon which they are far from agreeing. From a very early period, it was seen, that the skin was composed of two layers, one thick and deep, the other thin and superficial. Malpighi perceiving, that in a bullock's tongue, the papillæ of the dermis are separated from the epi-

* J. Ch. Th. Reusse, *præside* Autenrieth, *de Glandulis sebaceis dissert. etc.* Tubingœ, 1807.

dermis by a mucous or glutinous layer, which fills up the intervals like a net-work, transferred that layer, by analogy, to the skin of man; Ruysch afterwards gave a figure of this net-work. From that period anatomists have been singularly divided as to the existence of this membrane: some denying it entirely, and admitting only the dermis and epidermis as constituents of the skin; others admitting its existence in the coloured race only; others again improving upon Malpighi, and admitting of several layers in the mucous body of the skin, as many, as it were, as there are anatomical elements in that membrane, or as it exercises functions.

§ 296. The blood-vessels, lymphatics, and nerves of the skin penetrate, as they divide, through the areola of the dermis: supported by a fine cellular tissue which surrounds them, they thus attain its superficies, where they are increased to myriads, which by their ultimate divisions constitute the papillæ and the vascular net-work. As relates to the disposition of these parts, and particularly of the vessels, it has been generally conceded that they are foreign to the dermis, and that they merely traverse it to form the vascular net-work above. M. Chaussier, on the contrary, admits that all the anatomical elements of the skin are united in the dermis itself. Gordon even goes so far as to say that the injected dermis is every where equally vascular, as much so on its deep surface as on its superficies. To say that the vessels are foreign to the dermis, and that they merely form a sub-jacent layer to it, would be incorrect; but it would be equally so to affirm, that the vessels are as much divided, and are as numerous on the deep face of the dermis, as they are on its opposite one. The vessels divide and ramify in the dermis, as they penetrate into its thickness, and their last divisions, prodigiously multiplied, are distributed in the external surface of that membrane, and in the eminences that cover it, parts, consequently, much more vascular than the deep face. It is precisely the same as regards the nerves.

§ 297. The dermis or corium, *corium, derma, vera cutis*, is a fibro-cellular membrane, which constitutes the deep and principal layer, and almost all the thickness of the skin. Its

internal face, which is that of the skin, presents, in general, conical alveolar openings, directed obliquely into the thickness of the membrane. These areolæ, which are very large in the dermis of the hand, of the sole of the foot, of the back, of the abdomen, of the limbs; narrower in the neck, breast, and face particularly, are nearly invisible in the back of the hand and foot, forehead, scrotum and labia pudendi. The edges of these areolæ are continued, the first and largest along with the subcutaneous fibrous tissue; the second with the more or less dense cellular tissue; the last or narrowest, with the very loose tissue that is found in the regions where they are observed; the areola themselves are filled with an adipose cellular tissue, and are traversed by the nerves and vessels of the skin. The bottom of these alveolar cavities is perforated by very small holes, which correspond to the superficial face of the dermis. This face tolerably smooth, in general, presents, in various places, little papillary eminences, that are much more apparent on the denuded dermis, than when seen through the epidermis.

§ 298. The papillary body, and the vascular net-work of the skin, which have been unhappily described as being distinct layers of this membrane, belong to the superficial face of the dermis. The papillæ* discovered by Malpighi, and since acknowledged, figured, and described by Ruysch, Albinus, and many other anatomists; lately described by Gautier, under the name of buds: and doubted by Cheselden and others, are very diminutive projections or eminences, generally conoid on the surface of the dermis; perfectly visible on the tongue, arranged in double lines, and very distinct in the palms of the hands, soles of the feet, and pulp of the fingers; still distinct, but irregularly distributed in the nipple and lips; but so extremely small and undistinguishable in the rest of the skin, that they have been admitted to exist there more from analogy, than from actual observation, and that they are confounded in the surface of the dermis in a vascular and nervous net-work. These papillæ, in those places where they are very distinct,

* Hintze, *de papillis cutis tactui inservientibus*. L. B. 1747—Albinus. *Acad. annot.* lib. iii. cap. ix. et xii.

evidently consist of a very soft, very cellular projection of the dermis, penetrated by numerous nervous threads, deprived of the neurilema, and of vascular ramusculi, and having an erectile disposition which will be described hereafter (*chap.* iv). In those places where the papillæ are less distinct, although the texture and composition of the dermis are essentially the same, there are fewer nerves; the vessels, which are very abundant, form a net-work. The blood penetrates constantly, but in variable quantities into the vessels of the dermis. In echymosis of the skin it goes still further, and passes into the mucous body. Fine and penetrating injections, after filling the papillary and vascular body of the skin, sometimes spread beyond it.*

§ 299. The texture of the dermis is that of an areolar web more or less close: the fibre that forms it is peculiar to it. It was considered by the older anatomists as intermediate to the muscular fibre, and the aponeurotic tissue. Some have stated it to be altogether cellular, others ligamentous. Even quite recently, M. Osiander† has maintained that it is distinctly muscular on the internal face of the skin. His observations were made on the skin of the abdomen in women who died in parturition. The tissues to which it bears the greatest resemblance by the ensemble of its characters, are, the cellular and fibrous tissues.

§ 300. The dermis is white: its external surface is more or less reddish, according to the greater or less quantity of blood, remaining in its small vessels. Its thickness is not every where the same, varying from one line and a half, to a fourth of a line. In the trunk it is generally greater behind than before; in the limbs more so externally, than internally. The dermis is particularly very thin in the eye-lids, mammæ, and the organs of copulation; very thick, on the contrary, in the palm of the hands, and above all, in the sole of the foot. It has a semi-transparency which renders the colour of the sub-cutaneous veins visible through the skin. It has a power of re-

* *See* Prochaska, *disquisitio anat. phys. organismi &c.* Viennæ, 1812. 4°.
† *Commentationes gottingenses recentiores.* Vol. iv. 1820.

sistance or cohesion, which renders it, in the mechanical arts, fit for strong bands. It is submitted in the arts of the tanner, currier, &c. to various processes which prevent its putrefaction, and increase its density or flexibility, &c. It contains, naturally, a great quantity of moisture, whose abstraction renders it yellow and elastic. Decoction reduces it into glue or gelatine. Besides its extensibility and retractility, which are very great and which continue after death, it possesses, during life, a very evident tonic power of contraction, although in a much smaller degree than the muscles. It is this contraction which produces what is commonly called *goose-flesh.* It is its external surface that is the seat of the sense of touch. The dermis is the support of all the rest of the skin; the corpus mucosum is placed on its surface.

§ 301. The corpus mucosum, of Malpighi,* *reticulare corpus*, *rete glutinosum malpighianum*, is a very thin layer, of a semi-liquid cellular tissue, which clothes the papillary surface of the dermis, separates it from the epidermis, adheres closely to each of them, and is the seat of colouring matter. This part of the skin, indicated by Malpighi, well observed by Meckel and Albinus, acknowledged by most anatomists, at least in the negro, denied, however, by some of them, particularly by Bichat, M. Chaussier, Gordon, and M. Rudolphi, can not, it is true, be isolated by dissection, but may be seen in various circumstances. Whenever, either in life or death, the epidermis is separated from the dermis, we can perceive on one or the other, and sometimes on each of these membranes a mucous layer, which covers the papillary eminences, and fills up the spaces between them. This intermediate membrane, is particularly visible in the negro, very visible also in the black spots of the white man, and even very distinct on a piece of white skin, in the collection of Hunter. This layer, extremely thin on the summits of the papillæ, and less so in the intervals, has the appearance of a net-work, but is not perforated.

* *See* Meckel, *Recherches anatomiques sur la nature de l'epiderme et du réseau qu'on appelle malphigien*, *Mem. de l'acad. roy. des sc. de* Berlin. ann. 1753.—Albinus, *Academ. annot.* lib. i. cap. i.—v.

Those who admit of only two membranes in the skin, consider it as the deep part of the epidermis. This mucous body, of the nature of which it is difficult to form an exact idea, appears to consist of a plastic liquid or a semi-organized cellular tissue. Neither the blood, nor injections show any vessels in it; liquids penetrate into it, however, but they seem to be imbibed by it, or to be contained in peculiar interstices. Nerves are unknown in it, and it is by a pure allegation that Mr. Gall assimilates it to the grayish substance of the brain. This membrane forms a humid varnish which covers the papillary and vascular surface of the dermis. Substances which enter into, or depart from the economy by the skin, traverse it, it is the seat of colour, and that of the horny, scaly, &c. productions, that exist naturally in the skin of animals, and in some part of that of man, as well as of those that are accidentally developed there. This membrane, which is so thin, and whose existence has even appeared dubious, seems, in some animals, and even in man, at least in some parts of the body, and in certain cases, to be found of several superincumbent layers.

§ 302. An anonymous author had already pointed out this arrangement. Cruikshank observed it in a negro dead of small-pox; Bayham on the injected skin of a white man, in another case of disease; Gautier, by various processes, has demonstrated it on the skin of the negro, and M. Dutrochet on the skin of animals. This is a sufficient number of observations, to demand an examination before we reject them: 1st, on the papillary surface of the dermis, there is a very thin, colourless, transparent layer, particularly distinguishable under the scales and the coloured horns of animals, in the negro and even in the white man, but under the nails only; 2d, a coloured layer very distinct in negroes, in whites marked with coloured ephelides, and much less so where the skin is white; it is often united to the following; 3d, a superficial colourless layer, more or less soft or encrusted with a horny or calcarious substance; it is distinct in several animals, slightly in the negro, not at all in the white man, except in the nails, hairs and accidental horny productions. This layer is directly covered by the epidermis.

§ 303. The pigment of the skin* is chiefly seated in the corpus mucosum and particularly in its middle layer, but the external surface of the dermis and the internal one of the epidermis, also partly partake of it. Anatomists prior to Malpighi, and some even since, place its seat in these two membranes, particularly in the latter. The colouring matter exists in men of every race, albinos excepted. It is only in the negro, however, that it can be distinguished, clearly, from the rest of the skin. Malpighi had only announced, that the colour of the skin had its seat in the rete mucosum; Littre had tried, but in vain, to obtain the colouring matter, separately, by submitting the negro skin to maceration, in order to swell the mucous body, and thus to separate the epidermis from the dermis. Although the corpus mucosum is soft and liquefiable, we can succeed in separating from the skin of the negro scrotum considerable portions of the coloured mucous body in the form of a continuous independent membrane, separate from the epidermis. Most generally, however, and I have often tried the experiment, the maceration separates from the dermis, which remains but very slightly coloured, the epidermis and corpus mucosum united and coloured: it is only with great difficulty, that we can afterwards separate the mucous body in the form of a membrane. If the maceration be continued in a small quantity of water, and the experiment be made on the skin of the scrotum, a deeply coloured part, the mucous body in resolving itself into a sort of mucosity, tinges the water and finally deposits at the bottom of the vase, an impalpable brown powder. Gautier has assigned, as the special seat of the colouring matter, the middle layer of the corpus mucosum, which he describes under the name of *gemmules*, as an undulated layer, which, with a single one of its turns, would cover each one of the double furrowed lines of the dermis, of the palm of the hand, and the sole of the foot. It

* B. S. Albinus. *De sede et causâ coloris æthiopum etc. homin, etc.* Lugd-Bat. 1737, *et Annot.* lib. i. cap. ii. Meckel, *loc. cit.*—S T. Sœmmering, *Ueber die korperliche verschiedenheit des negers vom europaer.*

would rather appear, that the pigment results from coloured globules, disseminated through the corpus mucosum.

The mucous body is not only more coloured, it is also thicker in the negro. than in other races, and its thickness in the latter is in direct proportion to its colour; thus, it is so extremely thin in the white man, that its very existence has been doubted. It is still thinner and so liquid in albinos, that the action of the sun easily vesicates their skins, while in the negro it is with difficulty that epispastics produce that effect.

The colouring matter of the skin is very analogous to that of the blood; it appears to be secreted from that humour and to pass from the vessels of the surface of the dermis into the mucous body, where it is in a kind of imbibition. Various morbid phenomena induce a belief that it is continually renewed there, by an unceasing deposition and absorption. Beddoes and Fourcroy have observed by experiment, that the negro skin plunged into water, impregnated with the vapour of chlorine, becomes white, and in a few days resumes its black colour in all its intensity. The chemical observations of Davy, Coli and others have demonstrated that, which Blumenbach had long before asserted, viz: that the pigment of the skin is chiefly formed of carbon.

The use of the pigment in the coloured races, appears to be, to defend the skin against the rubefacient effect of the rays of the sun, commonly called a *coup de soleil.**

§ 304. The epidermis or cuticle, *epidermis*, *cuticula*,† is a distinct, though thin layer of the skin, which forms a kind of dry and defensive varnish on its surface. The free or superficial surface of this membrane, which is also that of the skin,

* *See Philosoph. Transact. ann.* 1821, I. *On the black rete mucosum, &c.* by Sir Ed. Home.

† H. Fabricio, *de totius animalis integumentis, ac primo de cuticula, et iis quæ supra cuticulam sunt.* in oper omn.—Ludwig *de cuticulâ.* Lipsiæ, 1739. —Meckel, *loc. cit et Nouvelles observations sur les l'épiderme.* Mem. de l'acad. roy. des sc. de Berlin, ann. 1757.—Monro, sen. *de cuticulâ humana, oratio,* in works. Edinb. 1781.—J. Th. Klinkosch et Hermann, *de vera naturæ cuticula ejusque regeneratione.* Pragæ, 1775.—B. Mojon, *Sull' epidermide, etc.* Genao, 1815.

presents, as we have already seen [292], little wrinkles and eminences variously arranged, and very visible to the naked eye. Moreover, if we examine this surface with a magnifying instrument, and even with a simple lens, the parts of the epidermis between the little wrinkles, and which to the naked eye seem united, then appears very unequal, rugous, and present little depressions, which bear the greater resemblance to pores, because we see the sweat oozing from them.

The deep face of the epidermis is adherent, and can not be separated from the rest of the skin by dissection, but putrefaction, maceration, the action of dry and humid heat, epispastics, and various diseases, produce this separation. When it is caused by incipient putrefaction, a process preferable to all others, by cautiously raising the epidermis, we perceive a multitude of very fine, transparent, colourless filaments, which break after being extended to a certain degree. These filaments, well described and represented by W. Hunter, who considered them as the vessels of the sweat, had been previously noticed by Kaau, who was of a similar opinion. Bichat and M. Chaussier, also, believed them to be exhalent and absorbing vessels. But we have not yet been able to inject them, and inflammation, which renders the skin so vascular, does not, sensibly, colour them. Cruikshank, on the other hand, thinks they are not vessels, but excessively fine prolongations of the epidermis, which line the smallest pores of the dermis. Seiler seems to adopt this hypothesis, and according to him, they are rudiments of sebaceous follicles and bulbs of hairs. It is not certain, however, that these prolongations exist when the epidermis adheres to the dermis, and we may consider them as mucous threads formed by the intermediate substance of the dermis, and epidermis rendered fluid and viscid by incipient decomposition.

The epidermis penetrates, as it becomes attenuated, into the sebaceous follicles. It penetrates, in like manner, into the openings of the bulbs of the hairs.

§ 305. It has been said that the epidermis was composed of imbricated scales; but this is a deceitful appearance, it is a flat and continuous membrane. Nunberger admits that it is fur-

nished with vessels, and that it is nourished by intus-susception. Mojon, like Klinkosch, supposes it to contain fibres, lamina, vessels, and all the properties of organization, and of life. Mascagni considers it as being entirely formed of absorbent vessels. Fontana had previously thought he saw spiral vessels in it, but M. de Humboldt found these supposed vessels were nothing more than folds. The most attentive examination, and the most delicate anatomical operations, can only show in the epidermis, one homogeneous layer, whose adhering surface becomes insensibly confounded with the mucous body, and which is deprived of cellular tissue, of vessels, and of nerves.

§ 306. The thickness of the epidermis is but trifling, being scarcely equal to the fifth or sixth part of that of the skin. It is thicker in the palm of the hand, and the sole of the foot, than any where else. In these places, particularly in mechanics, or in persons who walk much, it appears to be formed of several layers. M. Heusinger,* considers this part as a variety of the horny tissue, and has described it under the name of the callous tissue. The epidermis is not so elastic as the corium, is very flexible and easily torn. It is transparent, and of a light grayish colour. In the coloured races it partakes of the colour of the skin, but it is not so deep as the corpus mucosum. The transparency of the epidermis is not every where the same; if we look at it against the light, we perceive points more transparent than others, previously taken for pores.

§ 307. It is known that Leuwenhoeck thought he had perceived them, and that he has figured them. Many have admitted them from this, or from physiological considerations. But neither the observations of M. de Humboldt, made with magnifying instruments greatly superior to those of Leuwenhoeck, nor those of Seiler, made upon the epidermis detached by a razor, from the body of an animal while sweating, nor my own, made by charging a piece of epidermis with a column of mercury of about the weight of one atmosphere, have been able to discover these pores. Again, observation teaches us

* *System der histologia, von* Heusinger Eisenach. 1822. 4to.

that the epidermis prevents, or greatly moderates evaporation in the dead body, and that those places which are deprived of it, as well as the subjacent parts, become dry with great rapidity. The epidermis, however, permits those matters to pass which the skin absorbs during life, and certainly those it excretes. But what is more astonishing, is, that in the observations of which we have just spoken, no one has been able to perceive even the openings of the epidermis, through which the hairs pass, those which correspond to the sebaceous follicles, nor even those which had been made in it with a fine needle. The same thing, it is well known, happens in caoutchouc. Filtering paper presents no visible pores to the microscope while it is wet, but when dry they are very perceptible.

§ 308. It being impossible then, for cutaneous absorption and perspiration, to depend on the physical properties of the epidermis, an explanation has been sought for in its chemical properties. The dried epidermis diminishes in volume, becomes firmer, more elastic, and slightly yellowish. Macerated in cold water, on the contrary, it swells a little, becomes soft, less elastic, whiter and more opaque. It imbibes this fluid, however, very slowly, and it requires a long submersion of the hands and feet in water, for the epidermis to absorb a sufficiency of the liquid, to become white and opaque, and yet the epidermis of these regions appears to imbibe it more readily than that of the other parts of the body. It is to this difficulty of the permeability in the epidermis, that we are to attribute the difficulty with which the fluid of ampullæ escapes during life, and the slowness with which the skin of dead bodies dry even in the most arid atmosphere, provided the epidermis remains entire. It resists putrefaction for a long time; it has been found entire in tombs at the expiration of more than fifty years. Boiling water renders the epidermis white, opaque, and deprives it of its elasticity much quicker than cold water. Continued ebullition extracts a little gelatine from it, which appears to proceed from its adhering face; the residuum does not appear to differ from the entire epidermis. Exposed to fire it burns like horn, and gives out a similar odour. Pure

fixed alkalies resolve it completely into a saponaceous substance. Nitric acid turns it yellow almost at once, thickens, softens, and renders it opaque in about fifteen minutes, and in twenty-four hours reduces it to a yellow pulp. If ammonia is applied on the epidermis, rendered yellow by nitric acid, it changes to a deep orange colour. Now Hatchett has proved that similar effects took place on coagulated albumen. The epidermis appears to consist of a layer of albuminous mucus, coagulated and dried.

§ 309. The epidermis is neither irritable nor sensible; of all parts of the body it possesses the most active force of formation; it results from the concretion of a fluid exuded on the surface of the skin, constantly renewed, never absorbed, but destroyed externally as fast as it is produced on the internal face.

§ 310. Numerous hypotheses have been broached upon the formation of the epidermis; the most ancient, is that which teaches us to regard it as the drying of a fluid furnished by the surface of the dermis. Others, with Leuwenhoeck, saw nothing in it but an expansion of the vessels of the skin. Others again, as Ruysch, made it to consist of the expansion and drying of the papillæ. Heister attributed its formation to these two causes; Morgagni to the callification or induration of the surface of the skin, from the pressure of the waters of the amnios at first, and subsequently, from that of the atmosphere; and Garangeot to the induration of the rete mucosum. All these opinions, particularly the first and the last, contain some truth. It results, in fact, from an exudation or excretion of the dermis. It is the indurated surface of the corpus mucosum; so that from the dermis to the free surface of the epidermis, there is a successive deterioration of organization, and of vitality, which makes a kind of varnish of the epidermis, and participating in organization and life, only by its origin, a circumstance which renders it very fit to support the action of external bodies, and to protect the vessels, nerves, and other parts of the skin.

§ 311. The skin, formed by the dermis, the vessels and the nerves which are distributed through its thickness, and par-

ticularly on its superficial face; by the epidermis, of which we have been speaking, and by the intermediate mucous body, offering, thus, a diminution of organization, and of vitality, from the dermis to the epidermis, partakes of the physical, chemical, and vital properties of these various parts. It is the same with respect to its functions or organic actions.

§ 312. The skin, on account of the dry and slightly permeable epidermis, which makes a part of it, is not so well adapted for absorption and secretion as the mucous membrane.

The skin being furnished with its epidermis, in a state of integrity, cutaneous, or as it is also called, cuticular, absorption, is in fact, to this day, a subject of doubt and discussion among physiologists. To decide this question between Séguin, Currie, Klapp, Rousseau, Dangerfield, Chapman, Gordon, Magendie, &c., whose observations and experiments go to disprove the existence of cutaneous absorption, and Keil, Haller, Percival, Home, Cruikshank, Watson, Ford, Abernethy, Bichat, Duncan, Kelly, Bradner, Stewart, Sewall, &c., and M. Young in particular, whose experiments and observations are in favour of this absorption, we must abstract all those cases, and they are numerous, in which absorption may have taken place by respiration, as well as by the skin; those in which the epidermis may have been softened, altered, or abraded by continued applications to its surface, or by repeated rubbings, under which circumstances, absorption is no longer cuticular, but of the same kind to that which takes place in the mucous membrane, or by inoculation, when the matter is carried through the divided epidermis into the corpus mucosum, and even into the dermis, both parts being eminently absorbent. When this is done, there remains a small number of facts, which show, that certain substances are absorbed by the skin, through the epidermis, in its entire state, but that this membrane is truly an obstacle that very often prevents the absorbent power of the external tegument.

§ 313. The skin is also an organ of secretion and excretion. Two kinds of well known extrinsic secretion take place in this membrane, cutaneous perspiration and the sebaceous follicular secretion. Perspiration is sometimes vaporous and

insensible, and at others liquid and visible; in the latter case it is called sweat. This secretion is continual, and probably, essentially the same in both cases; but in the first it is insensible on account of its vaporisation. The secretion takes place in the skin, but by what vessels, we do not know; as to the ways by which it traverses the corpus mucosum and the epidermis, we are totally ignorant. It is likely that the perspiratory secretion takes places in the bottom of the microscopic incisures and depressions of the epidermis, a place where it is the least dry. The quantity of this secreted matter is very great, but difficult to determine. Sanctorius, whose experiments are so celebrated, had observed, that he lost five-eighths of the whole of his aliment by pulmonary and cutaneous perspiration. Among those who have repeated his experiments, Lavoisier and M. Séguin have made this distinction; they found that the cutaneous perspiration, is to the pulmonary perspiration on an average, as eleven is to seven. Cruikshank has tried to determine its nature, and found that it had all the properties of water, containing carbonic acid and an odorous. animal matter.

When the matter of perspiration is collected in the form of sweat, we see it appear on the surface of the skin in small drops, upon which Leuwenhoeck has made some interesting observations. Human sweat in a state of health is always acid, saltish, and odorous. According to Theuard it is formed of much water, a small quantity of acetic acid, of hydro chlorate of soda, and perhaps of potash, very little earthy phosphate, an atom of the oxide of iron, and of an inappreciable quantity of animal matter. M. Berzelius considers it as water holding in solution the hydro chlorates of potash and soda, lactic acid, lactate of soda, and a little animal matter.

The cutaneous perspiration, either sensible or insensible, must be regarded as one of the most important excretions of the organism. It is, besides, a potent mean of refrigeration and of resistance against too elevated a temperature. This function presents numerous varieties, according to the age, sex, the individual, external circumstances, the state of the other functions, the action of ingested or applied substances,

diseases, &c. It exercises great influence over the other functions.

§ 314. It is admitted that gaseous secretions and absorptions, analogous to those of the lungs, and constituting a sort of cutaneous respiration, take place through the skin. Thus, Spallanzani in the mollusca, Edwards in reptiles, and Jurine even in man, have seen the skin absorb oxygen. According to various natural philosophers and physiologists, gases are also excreted from the skin; but objections and experiments can be opposed to these assertions; the experiments of Priestly may also be opposed to those of Cruikshank, of Dr. McKenzie and of M. Ellis, which seem to favour the theory of a cutaneous excretion of carbone, which combines with the oxygen of the atmosphere to form carbonic acid. It is at any rate certain, that if in man, whose epidermis is dry, and whose pulmonary respiration is very great, the air exercises a vivifying action upon the blood which circulates in the skin, this action can in nowise supply that of the lungs.

§ 315. The skin excretes an oily matter,* that Cruikshank succeeded in obtaining, in the form of black tears, on the surface of a knitted woollen waistcoat that he wore night and day for a month in the heat of summer. Rubbed on paper, this matter acts like fat, it burns with a white flame and leaves a carbonaceous residuum. It is uncertain whether this oil, which has been said to be subcutaneous fat transuding through the skin, is produced by the same channels as the preceding, or the following.

§ 316. The cutaneous follicles secrete a sebaceous matter. This matter is thick, not glutinous, without any fibrous appearance when indurated; by suspension in water, by trituration, it forms a sort of emulsion, but it does not dissolve. Exposed to fire, it does not melt; it burns, leaving much charcoal. It chiefly contains cerumen, a proportion of oil, that may be separated from it by blotting paper. This matter is formed in the sebaceous follicles, whence by pressure it may be forced out in the form of little worms, and whence it na-

* Ludwig and Grutzmacher, *de Humore cutem inungente*. Lipsiæ, 1748.

turally oozes, to anoint the neighbouring skin, and principally to defend it from the action of water and excrementitious humours.

It is these three matters united which constitute the cutaneous excretion, an excretion that is very abundant, a part of which is continually evaporated, while the more fixed portions cover the skin, from which they are subsequently detached in the form of dirt. To these excretions must be added that of the epidermis, which is continually wearing away on its superficial face, and is as regularly reproduced on the opposite one.

§ 317. The skin is an organ of sensation. It is still more than the other tegumentary membrane, the organ of tact, general and passive, which makes us sensible of the presence of bodies, their temperature, &c.; moreover, and particularly in certain places, being provided with many vessels and nerves, and well fitted for adaptation to the forms of bodies, it is a special and active organ of touch. The tact and touch are so much the more delicate, as the papillæ are more developed and less covered.

§ 318. Finally, the skin is a defensive organ, not very efficient in man, but greatly so in particular animals, where the mucous body is the seat of horny and calcareous incrustations. It is evident that this organ, whose functions are as multiplied as its texture is complex, can not have one of its parts or one of its functions greatly developed, but at the expense of the others; consequently the thicker and more protecting the corpus mucosum and epidermis, the duller is the sense of touch.

§ 319. The embryo, until the middle of the second month, has no distinct skin. About this period, according to Autenrieth, the epidermis begins to appear. Until half the term of gestation, the skin remains thin, colourless and transparent: it then assumes a rosy hue until about the eighth month; at this epoch it becomes pale, except in the folds. In about four months and a half, the sebaceous follicles begin to be visible, on the head first, and subsequently in the other parts of the body: at seven months, the sebaceous or caseiform covering

of the skin, begins to show itself: at birth the skin is covered with it, and is of a rosy white; after birth, the skin soon acquires the colour peculiar to the race and increases in thickness and strength until the adult age; in old age it becomes dry, wrinkled, and gradually loses its colour.

The skin is thinner, finer and softer in females; but these characters sometimes disappear after the age of puberty.

§ 320. The differences presented by the skin in the various races, have been already noticed [112, 116.] Individuals of the coloured races and even negroes are born with nearly the same colour as whites. The colour begins to show itself from the moment the child breathes, but particularly, about the third day after birth, round the nails, nipples, eyes, anus, and the organs of copulation; by the seventh day the colouring is everywhere extended, the palm of the hand and sole of the foot excepted, which remain whitish. The colour is not intense during the first year, it afterwards augments, and continues for the greater portion of life to diminish in old age. The odour of the skin, like its colour, varies in the races. Independently of national varieties, they are many among individuals.

§ 321. The morbid alterations of the skin are extremely numerous. We have already spoken of cicatrices or of accidental reproductions of this membrane [258.] The new tissue is analogous to the old one, but is not the same. The dermis is more dense, less areolar, more compact, less vascular, and less papillary than that of the skin. The epidermis evidently exists on it, though quite recently this has been denied; it is an error. The corpus mucosum exists there also, as well as its coloured layer; and Camper is wrong when he asserts, that the cicatrices of the negro are white; the hue is merely a little different. Horny productions sometimes form upon the cicatrices; these accidental teguments are very liable to ulcerate.

Accidental skin is sometimes found in the cysts of the ovaries, it is probably an imperfect production of a fœtus, either engendered, or enveloped in the fœtal state, by the individual which contains them.

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§ 322. The skin sometimes presents primitive vices of conformation, either by deficiency, which causes divisions or denudations in the fœtus, or by excess, which forms folds or sacs more or less extensive. It presents also acquired vices of conformation; its distention, carried to a great degree, as for instance in pregnancy, separates, loosens the fibres of the dermis, and produces welts, after delivery, which at first are brown or blackish, that afterwards become and remain more white and shining than the rest of the skin. A more moderate and more continued degree of distention, produces a loss of its elasticity and retractility, and when it is removed leaves wrinkles more or less deep.

§ 323. The skin is the frequent seat of congestions, discharges, and inflammations, acute and chronic, whose various effects, either on the texture of the membrane, on its colour, or on the products of its secretion, have given rise to the establishment of fifty genera, and more than a hundred species of cutaneous diseases, consisting of pimples, scales, eruptions, ampullæ, pustules, vesicles, tubercles, spots, &c., respecting which the works of Plenck, Alibert, Willan, and Bateman, may be consulted with advantage.

§ 324. The retention of the sebaceous matter, and its accumulation in the follicles, give rise to the formation of tumours called *pimples*, when they are small, and which, when large, are confounded with the encysted tumours under the names of *wens*, *meliceris*, *steatomatous tumours*, and *atheromæ*. When the tumour is small, and the orifice of the follicle is not obliterated, the sebaceous matter may be forced out of it by pressure in the form of a worm, a circumstance, which has led some inattentive observers, who are fond of the marvellous, into error. When, on the contrary, the tumour has greatly increased, and grown voluminous under the skin, and its orifice is not apparent, it greatly resembles a cyst; but by dissecting it with care, traces of the orifice may be found in the point where it holds to the skin; and if we split the skin and the tumour in that point, we can easily follow the epidermis, which is reflected from the surface of the first into the cavity of the second. Whether the matter contained in it, resemble honey,

bouilli, or tallow, it is always sufficiently like the matter of the sebaceous follicles, to be recognised.

§ 325. Various accidental productions, either analogous or morbid, are observed in the skin. This membrane is sometimes raised up by a more or less great, and sometimes, an innumerable quantity of tumours, very various as to size, and formed by the accidental production of a white fibrous tissue, that is much more compact than the cellular tissue, and looser than the ligamentous tissue, one that is often found in polypi, and particularly in the sub-mucous tumours of the vagina and vulva.

§ 326. The colour of the skin presents various changes. That of the albinoes is the most singular: their skin is of a dead, or rosy white, very different from the white of Europeans; their hairs are transparent, whitish, or rather colourless; the iris of the eye is of a pale rose, and the opening of the pupil red, which is owing to the absence of the pigment of the choroides, and of the uvea. The functions of the skin, and particularly of the eyes, feel the effects of this alteration, which has been attributed to the absence of the mucous body, and which, at any rate, certainly depends upon that of the colouring matter of the skin and its appendages; it is wrong to regard it as the effect of a leprosy, a cachexia, or as a state of disease; it is an error of Blumenbach and Winterbottom, sufficiently refuted by the observations of Jefferson, who expressly declares, that all the individuals of this kind that he saw were well made, strong and healthy. This alteration is found in all the races of the human family, in every part of the globe, and in a great many genera of animals. It begins at birth, continues through life, and is transmitted by generation. The union of an albino and of a coloured person, generally produces coloured offspring, and sometimes albinoes. It does not, however, constitute a race in the human species, but is found sporadically, or as accidental varieties.

The nœvi and marks on the skin, consist, in some cases, of a coloured patch of the mucous body, which in this case is usually visibly thicker in that point than elsewhere; in others, they consist in an erectile disposition of the cutaneous vessels, which will be described hereafter. (*Chap.* iv.)

The colour of the skin is also subject to accidental alterations: thus we see individuals among the whites become brown, or perfectly black, in places of more or less extent. Whites and blacks also become albinoes in points of the skin more or less extensive.

May not the melanosis which usually coincides with the discolouration of the skin, and which is so often observed in white hairs, depend upon an aberration of the pigment of the skin?

Horny productions, which project more or less from the surface of the skin, are sometimes found in the corpus mucosum; these productions being analogous to the nails, will be described after these appendages of the skin.

ARTICLE II.

OF THE APPENDAGES OF THE SKIN.

§ 327. The nails and hairs are the only appendages of the human skin; in animals, on the contrary, they exist in great numbers and variety. It is an error to consider these parts as appendages of the epidermis alone, for they are connected with the whole skin.

1. OF THE NAILS.*

§ 328. The nails, *ungues*, are horny scales which cover the skin of the last phalanx of the fingers and toes, on the side of the extensors.

Three parts are noticed in the nail, viz: the root, the body, and the free extremity.

The root or adhering extremity, is the fifth or sixth part of the length of the nail; it is the thinnest part of it; it is received nto a groove in the skin, and is of a white colour. The body,

* Frankeneau, *de Unguibus.* Jenœ, 1796.—Ludwig, *de ortu et structurâ unguium.* Lipsiæ, 1748.—B. S. Albinus, *in Annot. acad.* lib. ii. cap. xiv. *de Ungue humano, ejusque reticulo &c., et* cap. xv. *de Natura unguis.*—Bose, *de Unguibus humanis.* Lips. 1773.—Haase, *de Nutritione unguium.* Lips. 1774.

or middle part, is of a middling thickness; its external free face is smooth, presents longitudinal furrows, more or less deep, and is transversely convex. Its opposite face adheres closely to the skin; the posterior part of the body of the nail, for a small extent and which gradually diminishes in proceeding from the thumb to the fourth or little finger, is white; this semi-lunar portion has been called the lunula; the other part appears reddish on account of its transparency, which renders visible the colour of the skin. The free extremity of the nail is its thickest part; it projects beyond the end of the finger and shows a tendency, although but slight, to curve into a sort of hook.

§ 329. The connexion of the nail with the dermis and epidermis is effected in the following manner: the dermis is thickened and very papillar beneath the body of the nail, under the lunule excepted; the papillæ are arranged in linear series like very delicate and closely approximated longitudinal sulci. The corresponding face of the nail is soft, pulpy and furnished with longitudinal grooves, which receive and adhere very closely to the papillary furrows of the dermis. Their separation, however, in the dead body, is produced by the same causes that separate the epidermis and mucous body from the dermis. The adhering extremity of the nail, very thin and very soft, is received into the bottom of a fold of the dermis, deprived of epidermis. Under the small and irregularly developed nails of the last toes, the papillæ of the dermis are arranged irregularly and not in linear series; the adhering face of the nail presents the same irregular disposition for the reception of the papillæ.

§ 330. The epidermis having arrived near the root of the nail, is reflected with the dermis to the bottom of the furrow. There the dermis passes under the nail; the epidermis on the contrary is reflected over its root, and is prolonged over its external face, which it thus covers with a very thin lamina, that is confounded with it. At the free extremity of the nail the epidermis of the end of the finger is reflected under its deep face and is united to the free part of that face. On the

sides there is, behind, a disposition analogous to that at the root, and before, to that of its free extremity.

The nails have no connections besides those just described. It is from want of observation that some anatomists have admitted them to have others with the periosteum and the tendons.

§ 331. Some have admitted, with Blaucardi, that the nails are formed of agglutinated hairs; others, that they result from the super-position of scales or horny laminæ, the uppermost of which is the whole length of the nail, while the others successively diminish in length, which occasions a regularly increasing thickness from the root to the free extremity. These are rather ways of accounting for the mode of the formation of the nails, than results of observation, which in fact discovers in the nails a horny substance only, hard and dry externally, and mucous in the interior. Neither vessels nor nerves are to be found in them. They consist in a thick and horny layer of the mucous body of the skin.

§ 332. The nails are diaphanous, flexible, and elastic; they may be torn crosswise, notwithstanding their fibrous appearance in another direction. Their chemical properties are those of coagulated albumen; they appear also to contain a little phosphate of lime; they are very similar to horn. They are totally deprived of irritability and sensibility. The force of formation or a continual growth by a sort of vegetation, is the only organic and vital phenomenon observed in them; even this is foreign to them. The materials of which they are formed, are continually and proportionably secreted and excreted by the dermis: this matter applied to the extremity and adhering face of the nail, like that of the secretion of the silk-worm, concreting as fast as it is excreted, and being continually added to that which has preceded it, pushes it before it, and thus lengthens the nail by juxta-position, and not by intus-susception. It is then a true excretion, whose materials, once deposited, are never absorbed. The nails arm, support and protect the extremity of the fingers and toes.

§ 333. The nails begin to appear about the middle of the fœtal term: even at birth they are still very imperfect. In

the coloured races, the colour is subjacent to the nail. In many animals, on the contrary, the coloured layer of the mucous body is confounded with the horny layer in the composition of the nails and similar parts. The parts most analogous to the nails of man are the claws of the carnivora, &c., which surround the dorsal face and the sides of the last phalanx, and are curved towards the sole; and the hoofs of the ruminantia, &c., which envelop the whole extremity of the last phalanx. The nails of the human foot have sometimes a considerable growth, and assume a direction that approximates them to claws.

§ 334. The alterations* attributed to the nails, are, in fact, utterly foreign to them, and depend wholly on the skin that produces them. It is the same with respect to accidental horny productions: it is in the subjacent tissue, that we must seek for their origin.

When a nail has been torn by violence, or detached by disease from the subjacent skin, it grows again slowly, and differs more or less from the primitive one, just as the affection of the skin continues more or less, at the time of its second growth.

Horny laminæ, more or less analogous to the nails, are formed upon cicatrices, the ends of the toes and other places exposed to pressure or violent and reiterated friction, such are callosities, &c. Simple ichthyosis, differs from them only in its extent and our ignorance of its cause.

Corns also consist of round, hard, small, accidental horny, productions, which by the compression they transmit, irritate, inflame and sometimes pierce the skin, and even affect the bones and subjacent articulations.

Horns or horny conoid productions more or less elongated, have been very often observed from the earliest ages on almost all parts of the skin. Sometimes a single one of these excrescences exist on an individual and is developed on a cicatrix, in a sebaceous follicle, or on some point of the skin, that has been previously altered, or even without any thing

* Plenck, *de morbis unguium, in doctrinâ de morbis cutaneis.*

particular in the skin having been marked; at others, productions of this kind exist on almost every part of the skin, constituting a species of ichthyosis.

The warts of the skin and those of the mucous membrane, may be approximated to the accidental horny productions, and be considered as an imperfect horny tissue, both of them participating in the horny tissue, and in that of the membrane.

In certain general as well as local affections of the skin, as well as the habitual contact of acids, &c. as happens in some professions, the nails soften, become fleshy, and imperfect horny tissue, vegetate irregularly, present excrescences, become dry, and fragile. They always partake of the healthy or diseased state of the skin of which they are a production. Inverted toe nail is merely the mechanical cause of an inflammation of the skin.

II. OF THE HAIRS.*

§ 335. Hairs, *pili, crines*, are horny filaments, generally fine and long, which in a greater or less number cover almost all parts of the skin, except the palm of the hand and the sole of the foot.

Each hair consists of a bulb and stem, and the texture of each of these parts is tolerably complex, particularly distinguishable in their most voluminous points.

336. The bulb or follicle of a hair, which Malpighi compared to the vases in which gardeners plant vegetables, and which has been ably described by Chirac, is situated in the thickness of the dermis or under it; it is of an ovoid form; by one of its extremities, which penetrates obliquely through the skin, it communicates with the surface of that membrane; and

* P. Chirac, *Lettre écrite á M. Regis sur la structure des cheveux.* Montpellier, 1688.—M. Malpighi, *de Pilis, obs. in op. posth.*—Withoff, *Anatome pili humani.* Duisb. 1750 *et in Comm. soc. scient.* Gotting. 1753.—J. H. Kniphof *de pilorum usu.* Erf. 1754.—Duverney, *Œuvres anatom.* Paris, 1761.—Albinus, *Acad. annot.* lib. iv. chap. ix.—T. P. Pfaff, *de variet. pilor. natural. et præternat.* Halæ, 1796.—Car. Asm. Rudolphi, *Diss. de pilorum structurá.* Gryphiswald, 1806.—Gautier, L. c.—Heusinger, L. c. &c.

by the other, which is deep and furnished with implanted filaments like roots, it is plunged into the sub-cutaneous cellular tissue. Externally, it is formed by a capsular, firm, coriacious, white membrane, which is continuous with the dermis by its superficial extremity. Inside this membrane is another, thinner, soft, reddish, or variously coloured, and which appears to be a continuation of the mucous body. The cavity of this membranous follicle is filled in a great measure by a bulb or conical papilla, adhering by its base to the bottom of the cavity and free at its summit, which rises towards the orifice of the follicle.

Blood vessels reach the papillæ, according to Gautier, by the mouth of the bulb, creeping between these two membranous layers, and according to my own observations, by the bottom. By dissection I have also followed nervous threads even into the root of the follicle, which I consequently consider as being formed by vessels, nerves and cellular tissue.

The bulbs of the hairs, then, seem to consist in a little piece of excavated skin, depressed or doubled over, surmounted by a papilla, and furnished with nerves and vessels, which, in comparison with the smallness of the space where they are distributed, are voluminous.

In the thickness of the neck of this piliferous bulb, we find several little sebaceous follicles, circularly arranged.

§ 237. The stem of the hair is planted by one of its extremities in the piliferous bulb, and is free for the rest of its extent. Its form is conoid, its free extremity being a little thinner than the rest. Its length is very variable, its thickness likewise. The base is hollow and lodged in the bulb where it embraces the papilla; the summit is often split; whatever be the colour of the hair, its root is always white and diaphanous; the portion contained within the bulb is always softer than the remainder, its most inferior portion, that which covers the papillæ, is perfectly fluid. It has been said, that the surface of the hair was scaly, or covered with microscopic asperities, free near the summit, and adherent at the root; I have never been able to see them.

§ 338. The connexion of the hair with the skin is effected

as follows: it is attached by its base, which is hollow, to the surface of the papilla; in addition to this, the epidermis, after being brought from the surface of the skin to the mouth of the bulb, is reflected on the base of the hair, is united to, and confounded with its surface; the hair is thus strongly connected with the skin, and can not be drawn with any force, without occasioning pain; the separation of the hair in the dead body, is effected by the same causes, which detach the nails and epidermis from the skin.

§ 339. The stem of a hair consists of a horny sheath that is diaphanous, and nearly colourless, and of an internal coloured substance, generally described as consisting of a certain number of filaments, said to be from five to ten, moistened with a colouring matter; some have asserted this sheath is filled with a spongy substance similar to that found in the stems of feathers; others have pretended that the internal filaments are vascular; it has also been affirmed that a hair consists of one, single, homogeneous, horny filament, which is not probable; Mascagni states it to be entirely formed of absorbent vessels. It appears, on the contrary, that the hairs, like the epidermis and horn, are totally deprived of vessels and nerves; that they simply consist in a prolongation of the two layers of the corpus mucosum, the horny layer, and the coloured layer, to which is joined the epidermis.

§ 340. The colour of the hairs generally, corresponds to that of the skin and eyes. In those individuals who have coloured spots, or albinous spots, the hairs are coloured in the former, and white or colourless in the latter. They are very strong, and support considerable weight without breaking. They are easily torn or split lengthwise. They are very hygroscopic, moisture swells and lengthens them, dryness shortens them: Saussure has profited by this phenomenon in the construction of the hygrometer that bears his name. They are idio-electric. They depolarize light, and according to Dr. Brewster, their axes are perfectly neuter, being parallel and perpendicular to the axes of the hair.

According to Mr. Hatchett, a continued ebullition of the hairs, deprives them of a little gelatine, while the remaining

substance, which loses a portion of the elasticity and tenacity of the hair, has all the properties of coagulated albumen. They strongly resist putrefaction. Their colour changes at first, but the corneous matter resists for a great length of time. Vauquelin has found that they dissolve in Papin's digester; that they are dissolved by water containing four hundredths of caustic potash; and that they are acted on by all the acids. According to this celebrated chemist, they are composed of an animal matter which forms their base, of a small quantity of a white concrete oil, of a blackish oil, of iron, oxide of manganese, phosphate of lime, carbonate of lime, silex and sulphur.

§ 341. They are neither irritable nor sensible; their force of formation or vegetative power is very active.

The motions of the hairs are communicated to them by the sub-cutaneous muscles, and by the contraction of the skin itself. Each of the large hairs or prickles of certain animals, are, in addition, provided at the root with a little muscle destined to elevate it. Although, strictly speaking, the stems of the hairs are insensible, yet as their roots are placed over a papilla provided with a nerve, they transmit to it with great accuracy the effects of contact with external bodies that act on them mechanically. Their production or vegetation is continual, it is analogous to that of the epidermis and the nails, and like it, constitutes a true excretion. Certain facts seem to indicate, that there occurs in their interior, not a true circulation, but an imbibition, and that a coloured liquid slowly traverses them from the root towards the summit. They have been stated, without any proof, to be organs of absorption. Their use is to protect the skin, and in some places, particularly, to serve the purposes of sensation. They have also local uses.

§ 342. The hairs present considerable differences, relative to the regions they occupy, and have received various names.

On the cranium they are called, *hair*, *capilli*, *coma*, *cæsaries:* these hairs are the longest, the most numerous, strongest and thickly set.

The brows and lashes belong to the eyes; the orifices of the nostrils and ears are also furnished with hairs.

The cheeks, the environs of the mouth and chin are occupied by the *beard*, *barba*, *julus*, *mystax*, *pappus*.

The groin is furnished with them, *glandebalæ*, as well as the pubis, *pubes*, the scrotum labia pudendi, and around the anus.

The rest of the body, both trunk and limbs, are more or less possessed of them. On the trunk they are more numerous on the anterior than the dorsal face, which is precisely the reverse of what generally takes place in animals; in the limbs there are fewer on the internal side than the external one. The hairs of the greater part of the body and limbs are thinly scattered, very fine, short, and scarcely visible; they have no particular names, and are in great numbers and highly developed in particular hairy individuals, *homines pilosi.*

§ 343. The rudiments of the hairs are perceptible on the fœtus about the middle period of pregnancy. They make their appearance in the mucous body in form of globules similar to those of the pigment. On these globules arise little hollow cones, the sheaths of the hairs. They remain for some time under the epidermis, and finally traverse it obliquely, through pores, it has been said, but none are to be found.

At an early period, on the skin of the fœtus, is found a fine down, *lanugo*, at first colourless, that covers the whole of the body, and which assumes in the different regions determinate directions. These silky hairs, are, for the most part, detached about the eighth month of gestation, and are found in the water of the amnios, and in the meconium. It is in the last month that the eye-brows, eye-lashes, and the hair begin to appear. After birth the remainder of the down falls. At the age of puberty begin to appear the beard, the hairs of the nose and ear, those of the axillæ, the pubis, the organs of copulation, the anus, and those of the rest of the body. After the adult period of life, and in old age, the hairs generally become white and fall.

The hairs of the head are generally longest, and most numerous in females; they have, generally, no beard, nor hairs round the anus, and those of the remainder of the body are finer and more thinly scattered. After the age of fecundity the beard

is sometimes developed. Women in general, are less liable to become bald than men.

The human races, as regards hairs, present differences that have been already pointed out. (112—117.)

Individuals also present numerous ones; some of which relate to colour, of which there are a great variety of shades; others to their thickness, number and length. Withoff found that on a portion of skin one fourth of an inch square, there were 147 black hairs, 162 chestnut, and 182 auburn.

Parts highly analogous to hairs, are found in some of the mammalia where they constitute spines; they are horny sheaths, coloured, hard, and pointed, and containing internally, a white spongy substance that has but little solidity; such are the quills of the porcupine. The ordinary hairs seem principally to consist of the former substance.

§ 344. Accidental hairs are found on various parts of the skin and mucous membrane, as well as in cysts. A popular error existed among the ancients respecting the heart, which was said to have been covered with hair, accredited by Plutarch and Pliny. Homer, according to some, talks of the hairy heart of Achilles; but it appears that it is of the hairy breast of his hero that he really speaks. As to the other facts, it would appear, according to the remark of Sénac, that the whole matter relates to hearts bristled with accidental cellular tissue. The accidental hairs of the skin are those which are found on coloured spots, or on parts of the skin that are thicker than the rest of that membrane; they have been known to acquire considerable development on portions of skin previously inflamed. Hairs have often been seen growing from various parts of the mucous membrane; most generally they have been found in cavities lined by that membrane, or ejected either alone, or as parts of concretions. Although many of these facts are well authenticated, we must not forget, that hairs may be swallowed or otherwise introduced. The hairs of the cysts, either cutaneous or mucous, are sometimes fixed, and at others free, and in ordinary cases are mixed with fat or sebaceous matter. Those that are fixed in the cysts of the ovary, are in general very evidently placed on the cutaneous parts of those cysts.

As to those of the wens of the eye-brow, of the cranium, &c. they appear to me to be nothing more than sebaceous follicles, and the hairs they contain, than hairs of the skin, which instead of being directed to the surface of that membrane through the orifice of the follicle, have been turned aside by the accidental enlargement of that cavity.

§ 345. These alterations of the hairs* like those of the nails, have all their origin and cause in the generating parts; the horny part produced, suffers its effects. When a hair has been torn out by violence or has fallen by the effect of a disease of the skin, and this has ceased, it grows again and increases by the same organic process as the nails. This regeneration is effected in the same way as in the first production [343.] When from age or other causes, the hairs begin to whiten, it is by its free extremity the albinism begins; the autumnal whitening of many animals takes place in a similar mode, which seems decisively to indicate, that the interior of the hair is the seat of a sort of imbibition, the matter of which is furnished by the papillæ of the bulb or follicle. This would also seem to be indicated by the circumstance, that after severe fevers, and in many chronic diseases, the hairs of the head, when they do not fall, undergo a kind of diminution or atrophy; they become transparent, dry and brittle, and when health is restored, resume their original qualities. The hair of the head has also been seen, after or without experiencing the change produced by albinism, to change colour and become black. The morbid phenomenon of the *plica polonica*, in which the hair is said to become soft and fleshy, and to bleed when cut close to the skin, forms no exception to the general proposition, that the stem of the hair only participates in the healthy or morbid state of the skin. It may, in fact, easily be conceded, that the papillæ of the hair, if it is inflamed, may rise, contained within the root of the hair to the level of the skin, and that its vascular tissue may be wounded in cutting the stem of the hair, but there is not much exaggeration in what is related concerning this affection.

* Plenck, *de Morbis capillorum, in op. cit.*—W. Wedenmeyer, *Historia pathol. pilorum.* Gotting. 1812, 4to.

CHAPTER IV.

OF THE VASCULAR SYSTEM.

§ 346. The vascular system, *systema vasorum*, results from the union of a multitude of ramified canals, communicating with each other, and in which the nutritive fluids continually circulate throughout the whole body; receiving at the tegumentary surfaces the substances of extrinsic absorption, and there yielding those of the excreting secretion; alternately depositing in and taking from the close cavities of the serous membranes, and the areolæ of the cellular tissue, continually furnishing the substance of the organs with materials of composition, and constantly conveying away those of decomposition.

§ 347. In the simplest animals, the whole mass of the body, every way equally permeable, is directly imbibed with the matters of absorption, and throws out in as simple a manner those of excretion; in animals placed a little higher in the scale of organization, the tegument, the essential seat of absorption and extrinsic secretion, is more or less ramified in the mass of the body, by means of which the substances for absorption are distributed, and those of excretion drawn from, the diverse parts of the mass of the body; finally in those of a still higher degree, and which embraces a great part of the animal kingdom, we observe vessels penetrating the mass of the body and ramified in every direction, every way distributing and taking up again the matter destined for nutrition.

§ 348. In man, as well as in many other animals, the blood contained in the vessels, is continually conveyed from a central point to every part, and returned from all parts to the centre, so as to describe a circle; hence to this vascular system

and its dependences the name of circulatory apparatus is given; the second name relating to the formation, and the first to the function.

This system comprehends three species of organs, two of which, the arteries and the veins, contain blood; the arteries convey it to every part of the body, and the veins bring it back from these parts; the arteries and veins are united at the centre by means of a hollow and muscular organ, the heart. The third species, the lymphatic vessels, convey, not blood, but chyle and lymph, and pour them into the veins; they should be considered as an appendage of the venous system.

§ 349. The arteries and the veins are in such relation with the heart and the blood, that they may be farther divided into two other sections.

The blood is brought by the veins from all parts of the body to the heart, and hence conveyed to the lungs by the pulmonary artery; it returns from the lungs by the pulmonary veins to the heart, hence to be conveyed by the aorta to every part of the body, from which it is brought back again by the venæ cavæ. The name of pulmonary, or small circulation, is given to the short circuit of the blood from the heart to the lungs and from the lungs to the heart, and the name of pulmonary vessels to the tubes, which give rise to this circulation. The name of general or great circulation is given to the course of the blood from the heart to all parts of the body, and from these parts to the heart, and the name of aorta and of venæ cavæ, or of general vessels, to those that are traversed by the blood in this circle.

§ 350. The blood contained in the general veins of the body, in the anterior or right side of the heart and in the pulmonary artery, is of a brownish red colour; it is called venous: that which is contained in the pulmonary veins, the other half of the heart and the aorta and its branches, is of a vermilion or arterial red. Circulation has also been divided, according to the blood that it contains, into that of black blood and into that of red blood. Bichat, author of this division, which had been perceived by Galen (*sect.* ii.), has thought proper to describe the first mentioned part of the circulation, under the

name of vascular system with black blood, and that mentioned in the second place, under the name of vascular system with red blood. It is easy to perceive that this division, pregnant with practical results, is entirely founded on a physiological basis, and not on the resemblance of the texture of the parts.

§ 351. The three species of vessels having a very great analogy with each other; the two sanguineous vascular systems having especially great relation with each other; and the venous and lymphatic systems also greatly resembling each other, we must, before describing each species, present the general considerations just alluded to, those which relate to the vessels generally, as well as those which refer to their terminations.

SECTION I.

ARTICLE I.

OF THE VESSELS IN GENERAL.

§ 352. The situation of the vessels is interior or deep seated. The largest are generally placed towards the centre of the body, and at the surface very small ones only are found, and even in this case, they are separated from external bodies by a layer of substance which is not vascular.

The principal vessels, either in the trunk or in the limbs, are generally placed in the same directions as that of the flexion of the parts. We generally find together an artery, one or two veins, and several lymphatic vessels; besides, we meet with many lymphatic vessels and veins under the skin, and but few arteries.

§ 353. The respective volume of the three kinds of vessels is such, generally, that the vessels which return the fluids, that is to say, the veins and lymphatics, are, taken as a whole, much more voluminous than the arteries. The veins alone are generally much more capacious than the arteries to which

they correspond; this holds good, particularly with respect to the larger vessels of the body. As to the relation of volume and number, or of the total capacity between the venous and lymphatic vessels, it is less known; it is very well known, however, that under the skin, the mucous membranes, and around the serous membranes, there are a great many veins and lymphatic vessels; that in the muscular interstices of the limbs, and of the parietes of the trunk, there are also numerous lymphatic vessels with the veins, while in the spinal canal, and within the cranium there exists a great many voluminous veins, and few or perhaps no lymphatic vessels. Do these relations depend on the difference of the matter with which the muscles and the nervous substance are nourished, and consequently on the different matter which remains in the circulation?

§ 354. The external form of the vascular system is that of a tree, the trunk of which is attached to the heart, and which is successively divided into branches, and ramusculi which become smaller and smaller branches. Each part, from its origin in a larger branch to its division in smaller ones, generally preserves a cylindrical form. Each branch being smaller than the one from which it proceeds, and larger than each of the ramusculi arising from it, the result is a successive diminution from the trunk to the end of each of these last ramifications. Since, generally speaking, the sum of the branches resulting from the division of a trunk, is greater than the volume of the trunk itself, it follows, that the vascular system has the form of a cone whose summit is at the heart, and whose base is formed by the union of all the branches ramified in the body.

§ 355. The number of the divisions of the vascular system, from its centre or origin, to its last sub-divisions, is not the same in all its parts. It has been very much exaggerated in computing it at forty; Haller was nearer to the truth, in considering the maximum of the successive divisions of a vessel from its trunk to its last ramifications to be about twenty.

In certain places vessels are divided, and form a bifurcation in such a manner, that the trunk terminates by its division into two branches, and the branch, by its separation, into two small

twigs. Thus the aorta bifurcates and forms the primitive iliacs, these latter bifurcate also in their turn; the primitive carotids are also divided into two smaller branches. The intestinal vessels present this dichotomic division in a remarkable manner.

The angles that the vessels form in dividing, and at which the branches are separated from the main trunks, vary, but the greater number are acute towards their smaller branches. We should observe with Haller, that these angles, to which much importance was formerly attached, are mostly destroyed or changed by dissection, and by removing the cellular tissue which surrounds the vessels. Some of the angles are nearly right angles; these are generally the first and the largest divisions of the trunks: for instance, the branches of the curvature of the aorta, the cœliac, the renal arteries, &c.; the renal and hepatic veins, the sub-clavian veins, the jugulars, &c.; the thoracic duct at its entrance into the left sub-clavian vein, and some others, such as the median artery (*sacra media*) &c. Some vessels form even obtuse angles, such are the first intercostal vessels, the inferior vessels of the cerebellum, those of the heart,* and some vessels of the limbs, &c. The greater number finally form acute angles, and often very acute, such are, for instance, the spermatic vessels.

We must observe with respect to the angles, which are considered as being right angles, and even obtuse, that the greater number are really acute; but at a small distance from the origin, the branches after a little distance change their direction, bending their course in contrary direction from that of the trunk, resembling very much the bent of the limbs of the weeping willow.

No law or general rule can be deduced from the observation of the angles formed by the divisions of the vessels. Thus we observe the bifurcations or divisions, and sub-divisions of the vessels of every size, to form angles more or less acute.

What is true of the large vessels, is equally so of the smallest,

* The coronary vessels might, with propriety, have been enumerated first among those which form an obtuse angle, with the main trunk from which they arise. TRANS.

in the divisions of which we, in like manner, generally find acute angles, some right angles, and even some obtuse ones.

§ 356. The branches of the different parts of the vascular system, at the same times that they divide or ramify, in proportion as they are removed from the centre of the system, nevertheless communicate or anastomose with each other. The lymphatic vessels are those which have the greatest number of these communications; in the veins there are a great many, in the arteries there are fewer, and nevertheless they possess a considerable number. These anastomoses occur by the union of two vessels of the same kind, and of an equal volume or calibre.

In some parts, two vessels approach each other obliquely, unite in a single trunk, which follows the mean direction of the two vessels; such is the union of the two vertebral arteries, in order to form the basilar artery, that of the anterior spinal arteries, that of the aorta, and of the pulmonary artery in the fœtus, that of a great many veins, &c.

Generally, vessels anastomose in such a manner as to form by their union an arch, from the convexity of which arise many branches; this arrangement is observed in the mesenteric or intestinal vessels, about the articulations, in the hand, in the foot, &c.

In other places two vessels, each following its direction, communicate by a transverse branch; such is, for instance, the communication between the umbilical arteries in the placenta; such are those of the brain, of the right with the left side, and of the anterior with the posterior part; such are also those of a great many veins and arteries of the limbs.

In several places, these various and more or less numerous communications form circles or polygons, like the circle of Willis, at the base of the brain; those of the iris and mouth, that which encircles the stomach, &c.

In a great number of parts, or almost every way, the vessels which anastomose in an arch, uniting likewise with others proceeding from branches, some being near, and others farther removed from the centre of the vascular system, establish collateral ways of circulation: thus, for instance, the circum-

flexa ilii communicate at the same time above with the vessels of the trunk, and below with the vessels of the knee, and these vessels at the same time communicate also with the branches proceeding from the vessels of the leg.

Generally the vessel or vessels which result from an anastomosis, are more voluminous than either of the anastomosing vessels and less than both united.

Anastomoses are so much the more frequent as they occur between smaller vessels and in parts the more distant from the centre; they occur also between larger branches in the extremities; for instance, in the cavity of the cranium, in the hand and in the foot. In most cases they establish a communication between vessels, whose origin is very near; in some cases they cause vessels, the origin of which is pretty distant, or even very distant, as for instance, from the subclavicular to the inguinal regions. The anastomoses of the sanguineous vessels are more numerous and larger around the articulation, than in the parts between them; those of the veins and of the lymphatic vessels are very frequent between the principal trunks; those of the veins particularly, are much multiplied under the skin.

We may form an idea of the number and importance of anastomoses since the aorta* may be narrowed, obliterated, even tied without preventing the circulation or the injection to reach every part of the body; that the largest veins,† even the venæ cavæ being obliterated, nevertheless the blood circulates; and that the thoracic duct‡ has been obliterated or tied with impunity.

Anastomoses facilitate and render more uniform the circulation of the fluids of the body.

§ 357. The larger vessels follow a pretty straight course, generally parallel to the axis of the body; this is the reason

* Scarpa *on Aneurism*.—A. Cooper and B. Travers' *Surgical Essays*, part i. Lond. 1818.

† J. Hodgson, *Affections of the Arteries and Veins.*

‡ Flandrin, *Journal de Medicine*, tom. lxxxvii. Paris, 1791.—A. Cooper, in *Medical Records and Researches, &c.* Lond. 1813.

why surgeons prefer making their incisions in the longitudinal direction, in order to avoid wounding them.

In many places, however, vessels have a fluctuating course. The fluctuation of the vessel consists in a deviation or alternate undulation of the vessels from a straight line; it increases when the vessels are turgid, or when a subject is injected, and in the arteries during the systole of the heart; it diminishes under opposite circumstances, and especially by closely dissecting the vessels. In the vessels of the parts subject to great change of volume, figure and situation, this fluctuation is very well marked; as for instance, the mouth, stomach, intestine, bladder, uterus, the tongue, and testicles before they descend from the abdomen, and those immediately surrounding the articulations: in these latter, however, there is less fluctuation, but the vessels are very elastic.

The vessels of the spleen and brain, and the spermatic veins, form also a great many windings, although they appear not to be intended for the same use.

The fluctuations of the sanguineous vessels are more strongly marked than those of the lymphatic vessels, and those of the arteries more than those of the veins.

§ 358. The symmetrical distribution of the vessels is very imperfect. This does not exist in the central parts; they are very nearly symmetrical as to their divisions, which belong to symmetrical parts, and have no symmetry in those belonging to parts which are not symmetrical. The arteries, the veins and lymphatic vessels present equally this disposition. In certain animals and in the embryo, the vascular system is more symmetrical than in the adult man. Moreover, besides the general want of symmetry, the vascular system is also subject to many irregularities in its distribution.

§ 359. The parietes of the vessels adhere by their external surface to the mass of the body in which they are ramified; their internal surface is smooth, polished, humid, and in contact with the circulating fluids; it presents a projection wherever the branches form acute angles with the trunks. The thickness of the parietes, when compared with the relative

volume of the vessel, increases from the trunk to its ramifications. The cavity presents exactly, as we have already said [354,] of the vessels themselves, the cylindric form in each division; that of a cone diminishing in size from the trunk to one of the last divisions; and that of a cone increasing from the trunk to all its ramifications.

§ 360. The texture of vessels is formed of several layers placed one over the other, and more or less distinct.

The internal membrane is thin, whitish, more or less diaphanous, uniform, without any visible fibres, every way continuous, but different in the arteries and veins. It very much resembles serous membranes, and is moistened by a liquid, the origin of which is not well known. It forms, according to the different kinds of vessels, a greater or smaller number of valves or duplicatures, arranged in such a manner as to permit the passage of the fluids in the direction of the circulation, and preventing their retrograde course.

The external coat, which must not be confounded with the cellular sheath which closely surrounds the vessels, is thicker than the internal, is fibro-cellular, and is generally formed with filaments, which are oblique with respect to the direction of the vessel, and which decussate each other.

Between these two membranes, a third which is fibrous, is observed, it is distinct in all the arteries that can be dissected, as well as in the larger veins.

§ 361. The external membrane of the vascular system, and especially the middle coat or membrane of the vessels, which are provided with it, are formed with a particular fibre. This fibre has been named elastic fibre, elastic fibrous tissue, &c. although the greater number of the organs are elastic and fibrous, but because it possesses this property in the highest degree. Its elasticity had already been observed by Nicholls, J. Hunter, and Ed. Home;* some modern anatomists and chemists have made it an object of their study.†

It not only forms the parietes of the vessels, but of those of

* *Croonian, Lecture on Muscular Motion, in Philos. Trans. ann.* 1795.

† H. Hauff, *de systeme telæ elasticæ, &c.* Tubingæ, 1822.—Chevreul, from an unpublished note.

the air vessels of the lungs; it also lines some excretory ducts; it forms the envelope of the cavernous body and that of the spleen, and the yellow ligaments of the vertebræ; it forms moreover, in various animals, the posterior cervical ligament, an abdominal tunic to the larger mammiferous animals, the ligament which raises the nails of the cat, that which opens bivalve shells; and in the greater number of the mammiferous animals, it supplies the place of the little bones of the tympanum. But it is especially in the middle coat of the arteries, in the yellow ligaments, and in the ligamentum nuchæ, that its characters are most evident. It exists under two principal forms; that of a canal, as in the parietes of the arteries; and that of bundles, as in the yellow ligaments.

This fibre is opaque, of a yellowish white, dry, firm, always arranged in parallel or very slightly oblique bundles, never crossing each other, nor united by the celluar tissue, and very easy to divide. It is extremely elastic, and in some places it may be stretched twice its length; and afterwards it forcibly recoils on itself, resuming its former condition. Its strength in the living body is less than that of the muscular tissue, but is stronger than the latter in the cadaver. In both these states it is much less than that of the ligamentous tissue, which it is almost impossible to extend. It is more tenacious where it exists in bundles, and more brittle in the vessels.

The elastic tissue contains nearly one half of its weight of water; when it has lost its moisture by disseccation, it acquires a horny appearance, a dark yellow colour, and becomes brittle and diaphanous like horn. If plunged at this time in water, it absorbs with avidity, and assumes its weight, aspect, and former elasticity. It resists maceration for a long time, and the cellular tissue does not become apparent in its structure. The action of fire crisps it but little, and leaves behind very little charcoal. Decoction scarcely crisps it, and extracts from it a small quantity of gelatine, but never melts it, and this operation does not destroy its elasticity. Acids render it but little horny and do not make it transparent; it resists their action for a long time, or experiences no effect at all. Diluted

alkaline solutions do not alter its form, and dissolve it very little.

The greater number of these anatomical, physical or chemical characters, are altogether the reverse of those of the ligamentous tissue, and different from those of the muscular fibre, with which the elastic tissue has been very improperly confounded. It resembles, however, in some respects, the muscular fibre, and seems to be of a nature intermediate between this latter and the cellular and fibrous tissues.

Its vital properties are very obscure, especially in the ligaments, and even in the larger vessels. Its functions depend on its elasticity, which every way antagonises the action of gravitation, or that of the muscles.

§ 362. The parietes of the vessels are themselves provided with sanguineous and lymphatic vessels, *vasa vasorum.* The former may be perceived in all the vessels which are not less than half a line in diameter; but they can not be traced into the thickness of the inner membrane. The lymphatics can only be observed on the larger vessels. The vascular system is also provided with nerves* furnished by the spinal marrow, and by the great sympathetic, and which are distributed in the external parts of their parietes.

§ 363. The vessels whose trunk, branches, and the principal ramifications are placed in the common cellular tissue, after having divided, penetrate into the mass of the organs, there ramify to such an extent as to become invisible to the naked eye, and terminate as we shall mention presently; but the distention of the vessels in the organs varies in several points which it is necessary to treat of successively.

§ 364. Their origin is more or less distant from their termination, and consequently they have various lengths. Generally, vessels branch off from their trunk very near the organ to which they are destined. When this is not the case, it is owing to some local disposition. Thus the spermatic vessels have their origin at a great distance from the organs in which

* Wrisberg, *de Nervis arteries venasque comitantibus; in syllog. comm.* Gotting. 1800.

they terminate; because primitively the testicles and ovaries were situated near the kidneys.

§ 365. The number, the volume, and consequently the amount of vessels, as well as the quantity of liquid they carry, vary equally in the different organs. The greater number of organs receive several vessels of each kind: such are, for instance, the muscles, the bones, the encephalon, the stomach, the intestines, the uterus, &c.; some have only a single arterial and a venous trunk; such are the spleen, the kidneys, &c. The vessels, almost always, greatly subdivide at the surface of the organs before penetrating into their interior, as is observed in the brain, the bones, the muscles, &c.; sometimes they enter into an organ through one single point, and subdivide within its mass, such as, for instance, the spleen, the testicles, &c.

The amount of the vessels, resulting from their number, and from their volume, as well as the quantity of the fluid conveyed through them, vary greatly. The most vascular parts are the lungs, then the tegumentary membranes, the pia-mater and choroid; then the glands, the follicles, the vascular ganglions, the cortical substance of the brain, and the nervous ganglions; then the muscles, the periosteum, the adipose tissue, the medullary nervous substance, the bones, and the serous membranes; then the tendons, the ligaments; finally, the cartilages and the arachnoid are but little so or not at all; and the epidermis, the nails, the hair, the ivory, and the enamel of the teeth, seem to be altogether deprived of vessels.*

§ 366. Having arrived in the tissue of the organs, and having attained a degree of tenuity more or less great, the vessels, by their divisions and subdivisions, by their direction, and by their anastomoses, form a very minute net-work, the form of which, although very diversified, is always the same in the same parts. They present arborizations in the intestines and epididymis, stars on the liver, tufts on the tongue, tendrils in the placenta; they have the form of a bottle-brush in the spleen, resembling a bundle of rods in the muscles, curls in the testicles

* *See* Sœmmering, *de Corp. human. fabricâ*, V. iv. *angiologia*, 1800.—G. Prochaska, *Disquisitio anat. physiol. organismi corp. hum. &c. Viennæ*, 1812. Cap. ix. *De vasis sanguineis capillaribus, &c.*

and in the plexus choroides, fringes in the pia mater, a trellis in the pituitary membrane, tufts in the crystalline; they are arched in the iris, &c. These modes of formation are so constant and regular, that by examining with the microscope a small portion of a well injected organ, we may easily recognise to which part it belongs.*

§ 367. The vessels are more or less diaphanous, according to their thickness. They are whitish. Whatever the density of their parietes may be, especially at their inner surface, they are permeable in the cadaver, and even in the living body, either from without inwards, or from within outwards. Their tenacity or cohesion is considerable;† but is not the same in the three kinds, in every one of their parts, nor in the various coats with which they are composed. The same is the case with respect to their elasticity,‡ which is generally considerable, and which exists either in the fibres lengthwise, or in those encircling the vessels. They are evidently irritable, and their vital contractility is generally in an inverse ratio to their elasticity. They are not distinctly sensible. Their power of formation is very active.

§ 368. The vessels are canals through which the circulating humours continually pass and moisten every part of the body; they together with the heart are the organs or agents of this movement, both by their elasticity and by their organic or vital contractility.

§ 369. The formation and development of the vascular system, have been particularly observed in the chicken in its shell, rather less in the fœtus of the mammiferous animals, and little in the human species.

The veins, especially those of the umbilical vesicle, are formed before the heart and arteries. It is uncertain, if in the allantoid or umbilical vessels, the veins are also formed before

* *See* Sœmmering *loc cit.*—Prochaska *loc cit.*

† Cl. Wintringham, *experimental inquiry on some parts of the animal structure;* London, 1740.

‡ D. Hoffman, *Diss. inaug. med. de elasticitatis effectibus in machinâ humanâ;* 1734.

the arteries. It is very probable that in the body of the fœtus the arteries are formed before the veins.

The vessels are observed in the thickness of the umbilical membrane, under the form of small, rounded vesicles, and separated from each other; these vesicles augment in number and unite, which produces a very loose vascular net-work. Their first rudiments are in the beginning deprived of proper parietes, and consist in mere passages made in the substance of the membrane. This substance accumulates by degrees about their circumference, and this forms their parietes. The texture and composition of these parietes, are only developed in time.

As to the primitive simplicity of the circulation in the fœtus, its successive complication, the formation of the heart, that of the pulmonary vessels, &c. more particularly belongs to special anatomy, and especially to embryology,* than to general anatomy.

The number of the vessels generally and their diameter, and consequently their sum total, are, as relate to the mass of the body, so much the more considerable as the animal is nearer the time of its formation. The vessels, in general, especially the sanguiferous, and more particularly the arteries, acquire considerable density in old age.

§ 370. The circulating system presents little differences relative to the sexes; nevertheless the vessels are rather thicker and firmer in the males. There is no appreciable difference in the races of men.

Individual varieties, on the contrary, are very frequent and very numerous in this system; they consist particularly in differences of origin, volume, number and precise situation; they exist nearly in the same degree in the three species of vessels.

§ 371. Under many circumstances, accidental, and commonly very minute vessels, are formed.

Adhesions, at first simply glutinous, become afterwards vascular. The same is the case with respect to the accidental

* Ph. Beclard, *Embryologie on Essai anat. sur le fœtus humain*, in 4to. Paris, 1821.

teguments or cicatrices. All the accidental productions analogous to the organic tissues, are in the same condition. The greater number of morbid productions, which have no analogous case in the organism, are, on the contrary, deprived of vessels. These latter are formed in the cases alluded to in the same manner as in the embryo. The mass in which they are formed, consisting frequently in a coagulated liquid, at first without vessels, presents in the beginning isolated vesicles, by which uniting, form passages or canals through the substance, or without distinct and proper parietes; these vessels afterwards communicate with those of the surrounding organs; they frequently remain for some time more or less different, and not unfrequently always so, from the primitive natural vessels, either by their manner of dividing, or particularly by the absence or tenuity and softness of their parietes; in many cases, on the contrary, the vessels acquire in time a texture altogether similar to that of the other vessels.

§ 372. Amongst the alterations to which the vessels are subject, some are common to the three kinds; such as the dilatation and wounds; the others are peculiar to each of them. The former even present very considerable differences in each species, and require to be indicated separately.

ARTICLE II.

OF THE TERMINATION OF THE VESSELS.

§ 373. The terminations of the vessels, *fines vasorum*, are the last ramifications of the arteries and the first radicles of the veins and of the lymphatic vessels. Their knowledge is a subject of minute anatomical investigation, which has most exercised the patience of observers and the imagination of ctyologists, who expected, with some appearance of plausibility, to discover in it the secret of the greater number of the functions and of diseases.

§ 374. In almost every part of the body, the vascular terminations are branches and radicles of an extreme tenuity, and which can only be observed by the help of a microscope. In

some parts, these terminations, and especially the radicles of the veins, are larger, and possess an erectile power, which renders them susceptible of experiencing a more or less considerable expansion. Finally, in some others, the terminations of the vessels constitute, by their intermixture, and their communication, ganglions or particular vascular enlargements.

I. OF THE CAPILLARY VESSELS.

§ 375. The capillary or microscopic vessels,* *vasa capillaria*, thus called in consequence of their tenuity, are much finer than hairs, and can not be perceived with the naked eye; although the radicles of the lymphatic vessels participate in this characteristic, nevertheless, it is especially the sanguineous capillary vessels that we shall treat of in this place.

§ 376. The ancients, who were ignorant of the art of injecting vessels, and that of magnifying objects by the help of optical instruments, were not acquainted with the extreme vessels. They believed there was between the last ramifications of the arteries and the first of the veins, an extravasated, spongy and sanguineous substance, called *parenchyma* by Erasistratus, *haimalope* by Aræteus, and of which they believed the viscera were especially formed. This opinion, on the termination of the vessels, was adopted almost unanimously by all the anatomists, till the period of the discovery of the circulation of the blood, and since that time, by a considerable number of anatomists down to the present day.

The injections of Ent,† however, by demonstrating the direct passage, and without the extravasation of the injected liquid, from the arteries into the veins; the microscopical observations of Malpighi,‡ and of Leuwenhoeck,§ made on the transparent parts of reptiles, fishes, and even of bats, in which the blood is seen passing directly from the arteries into the veins; experiments and observations, repeated since a great

* Prochaska, *de vasis sanguin. capill.*; *in op. cit.*

† *Apologia pro circulat. sanguin*; *in op.* Leidæ, 1687.

‡ *De pulmonibus*, Epist. ii. *in oper. omn.*

§ *Exp. et contemp. arcan. natur. detect.* Epist. 65, 67, &c.

many times, must have caused, and indeed have generally caused to reject the supposed parenchyma interposed between the terminations of the arteries and veins, in rendering evident the ramifications which are not visible to the naked eye, the microscopical divisions, and thus establishing a direct communication between them.

Minute injections and microscopical observations, soon led anatomists to admit, that instead of the parenchyma of the ancients, every thing is composed of vessels in the body; an opinion which yet divides all the cultivators of the science.

§ 377. The sanguineous capillary vessels are the last ramifications of the arteries, and the first radicles of the veins, or rather they are intermediate between the arteries and veins, and, as has been remarked in comparing them to the portal system, foreign or indifferent to both. It is in these vessels that, insensibly and without any fixed point, the arteries are converted into veins; of which we may judge by the successive increase or diminution of the size of the vessels in the one or the other direction, by the direction in which the successive divisions or union are made, and at the extremity of the fins and the tail of fishes, by the opposite direction of the course of the blood. However, the capillary vessels have been generally described as the last divisions of the arteries, rather than the beginning of the veins. Whether this be well founded and depend upon the small veins being larger than the small arteries, acquiring a considerable volume after a few reunions; or whether it is because the veins, almost all provided with valves, and more difficult to inject than the arteries, have been less the object of investigation. These two reasons may have contributed to give more currency to the opinion in question.

§ 378. All the capillary vessels, however, have not the same volume. In this respect three degrees of them may be established, by taking as the largest those which begin to be invisible to the naked eye, and as the smallest those which admit only one single red globule of blood at a time, and the diameter of which, of course, is not much larger than the globule itself. (§ 72.)

The larger capillary vessels experience several successive divisions before they acquire a size capable of admitting a single red globule of blood.

These capillaries communicate together by an infinity of anastomoses so as to form a net-work. They constitute the largest portion of the circulating circle, the capacity of the arterial system continually increasing from its origin at the heart to the capillary vessels, and that of the venous system decreasing from the capillary vessels to the heart.

The circulating circle being double in man, there are two capillary systems: the one *general*, between the terminations of the aortic arteries, and the origin of the veins of the body; and the other *pulmonary*, at the extremities of the vessels which bear this name. It has been advanced, but without any positive proof to support the assertion, that the pulmonary capillary system is as capacious and contains as much blood as the general capillary system.

There are in the abdomen two other small capillary systems; one between the mesenteric arteries and veins, the other between the hepatic extremities of the vena porta and the origin of the hepatic veins.

§ 379. The texture of the capillary vessels can not be observed with the naked eye. These vessels have very thin and soft transparent parietes, invisible to the naked eye, and slightly visible with the microscope, very little different from the substance of organs, and also from the humours they convey. They seem rather formed out of the substance of the organs than provided with its own parietes. It is, however, very probable that the internal membrane of the vessels, at least, is continuous without any interruption, from the arteries to the veins.

In the living body they are only distinguished by the colour and the direction of the flow of the blood which they contain, and after death by the colour of the matter with which they are injected. They are distinguished from the spongy areolæ, and the accidental cavities of the cellular tissue, by their constant, continuous, and regular course.

§ 380. Although the parietes of all the vessels are permea-

ble, nevertheless, this property is particularly observable in the smallest vessels.

They are very extensible and very contractile. Irritability increases while elasticity diminishes in the vessels in the same degree as they approach their termination. The capillaries are the most irritable.* Their contractility is produced either by local and direct agents, or by the nervous system.

§ 381. It is in this part of the vascular system that the most important phenomena of the organism occur, at least of the vegetative functions. The capillary circulation, *i. e.* the passage of the blood through the vessels of this name, is, of all the parts of the circulation, that, which without being independent of the action of the heart, is the least under its control. It is the point of the circle at which the movement of the blood is slowest; it is that in which the blood, divided in very small streams, has the greatest number of points of contact with the parietes of the vessels, and the most influenced by the nervous action. The blood takes its regular course through the capillary system by going directly from the arteries to the veins; if it meets an obstacle, many anastomosing vessels are opened and permit it to continue its round. But this system may also be the seat of congestions, irritations, and constrictions, which change the ordinary course of the liquids. Thus the application of warm fluids, for a few minutes, to the lower extremities of a frog, produce a dilatation of the capillary vessels, a local and partial stoppage of the circulation, a congestion, in a word, it causes the tissues which were before white, to become very red. The same thing occurs, from various causes, on the mammiferous animals and on man. The application of cold or of a diluted acid produces entirely opposite effects. Mechanical or chemical irritation produces at first the latter effect, and afterwards, by a kind of attraction, a concentric afflux of the liquids which, in many vessels, are then pursuing a course opposite to that of the blood.

* Whytt, *Physiological Essays*, &c. Edin. 1761.—H. Van den Bosh, *über das Muskelwermogen der Haargefasschen.* Monast. 1786.

The blood becomes nevous in the general capillary system, and arterial in the pulmonary capillary system.

§ 382. The sanguineous capillary vessels, such as they have just been described, are not equally abundant, and have not the same volume in all the parts of the body. The amount of the vessels of each part may be esteemed by the redness that it acquires when congested or inflamed, as well as when it is injected: this latter method is even preferable. The most successful injections made, are those of Ruysch, Albinus, Lieberkuhn, Barth, Bleuland, Sœmmering, and Prochaska.

The injections of Ruysch, by filling the most minute vessels, gave rise to the opinion that the whole of the solid substance of the body is vascular. Ruysch himself, however, acknowledged, that there were in the body parts more or less vascular, and others were entirely deprived of vessels. Albinus, in examining injected parts while yet fresh, and also when dried, observed that even after the most successful injections, there remains always more or less substance which was not reached by the injection, according to the nature of the parts: he thus controverted an erroneous opinion, which had especially arisen from the examination of the parts while dried or macerated, so as to cause the parts which can not be injected to disappear, or to be destroyed.

Microscopical observations and different experiments on living bodies also show, that there are parts more or less vascular. Thus, if the mesentery or the webs of the feet of a living frog be examined with the microscope, we shall see that the most minute capillary vessels, those which admit only one globule, are separated by a considerable space, whilst in the pulmonary mucous membrane of the same animal it would be impossible to stick a very fine needle without opening several of these vessels; nor is there, on the surface of the skin of a living man, a point in which a needle would not produce the same effect; while in the ligamentous parts, in the nervous substance, in the cellular tissue, &c. considerable divisions may be made without causing a drop of blood to issue.

If all the solid parts were vascular, and entirely vascular, there would be no longer any difference between them, all

the organs would be homogeneous; there would be but one organ. This organic simplicity is only to be met with, on the contrary, in animals deprived of vessels.

§ 383. The amount of the sanguineous capillary vessels, and their proportion with the solid and non-injectable substance, are not less interesting than their disposition in the several parts of the body.

The cellular tissue can not be injected. The epidermis, the horny parts, the hair and teeth, are not injectable at all. The adipose lobules are surrounded with a very fine vascular net-work. Cartilages experience no change whatever by injection.

The serous and synovial membranes are but slightly reddened by injection, but the masses and the fringes of adipose matter are surrounded with a very beautiful vascular net-work. The skin is the most vascular part. The matter of injection sometimes transuded beyond the dermis into the mucous layer or corpus mucosum. The capillary vessels of the skin, which are at first of the first and second magnitude, acquire the greatest degree of tenuity in penetrating into the papillæ. The recent skin, immediately after being injected, is much more coloured at its external surface: it appears equally coloured throughout, when the uninjectable parts which concealed the vessels have disappeared in consequence of desiccation. The cutaneous and mucous follicles are furnished with a very loose vascular net-work. This is also the case with the microscopic alveoli of the mucous membrane of the stomach and intestines. The papillæ of the mucous membrane, like those of the skin, are furnished with an infinite number of capillary vessels, which is also the case with the villosities, at least their adherent extremity. The mucous membrane, in general, is still more injectable than the skin, that of the lungs, particularly, is so in the highest degree. The membrane of the pituitary sinuses is much less so than the rest. The conjunctiva reddens moderately, and less by injection than by inflammation. The mucous membrane of the excretory ducts, and the glands themselves, are provided with numerous capillary vessels.

The ligamentous tissue receives few blood vessels; the dura mater is somewhat rather better provided; and the periosteum is reddened a little by injection.

The bones have but a small number of vessels. The capillary vessels of the muscles are abundant; the smallest, which are tortuous, accompany and surround the muscular fibres, frequently anastomosing.

The nervous system is furnished with capillary vessels, which are more abundant in its envelopes and in the cineritious substance, than in the medullary substance. The pia mater and the neurilema generally, which differ in this respect from the envelopes of many of the viscera, contain the vessels until the greater part of them have acquired a capillary tenuity. The cineritious matter of the brain and the nervous ganglia possess a multitude of capillary vessels of all sizes. The white matter, on the contrary, either of the encephalon or nerves, possesses only very small capillary vessels, and in a smaller number.

§ 384. There is therefore in the different organs, a greater or less proportion of a substance not vascular, or which at least can not be shown to be so by injections.

Meyer,* having introduced a colouring matter into the blood, both by absorption and by injection, concluded, from the different colouring of the parts of the body, that there are two kinds of organs, one set composed for the greater part of capillary vessels, viz: the cellular tissue, the serous membrane, the tegumentary membranes, and the fibrous or ligamentous tissue; the other, more sparingly furnished with blood vessels, and formed of globules or of an organic pulp, viz: the glands, the bones, the muscles, and the medullary nervous substance

This proportion also changes with age; at the commencement, at least in the ovipara, the blood is seen and presents currents before there are solid parts; soon after, the walls of the vessels are formed. The younger the animal, and the nearer to the fœtal state, the greater is the proportion of ves-

* *Memoire sur l'absorption veineuse, &c. in deutches archiv, &c.* and in the *Journal complémentaire,* vol. xi.

sels over the non-injectable parts. In the same degree as it advances in age, on the contrary, the proportion of non-injectable parts increases, and that of the capillary vessels diminishes.

§ 385. Beyond the capillary blood vessels of the diameter of a coloured globule, are there other smaller vessels which afford a passage to the colourless part of the blood? This is a question of very difficult solution.

Boerhaave, Vieussens, Ferrein, Haller, Sœmmering, Bichat, Chaussier, and many modern anatomists and physiologists, admit serous vessels beyond the last blood vessels, and Bleuland even thinks he has demonstrated their existence.

On the other hand, Prochaska, Mascagni, Richerand, and several others, are of opinion that there are no vessels of this kind. It is necessary to examine the facts and reasons adduced in support of these opinions.

§ 386. Edmund King was one of the first who substituted for the hypothesis of the ancients, respecting the existence of a parenchyma in the viscera, that of a purely vascular structure, which supposes that there are serous vessels; for the last capillary blood vessels are far from occupying or forming the whole substance of the tissues.

Vieussens and Boerhaave especially, have admitted not only one, but several orders of decreasing and colourless vessels. The disciples of Boerhaave, Haller, the most celebrated of them, and most of the physiologists up to the present time, have also admitted serous vessels, forming a continuation of the arteries beyond the point at which the veins begin. They found their opinion upon the microscopical observations of Leuwenhoek, who speaks of vessels admitting only serous globules, upon the phenomena of injection, and particularly on those of inflammations, which renders parts naturally white and transparent, more or less red.

We may add to this, that red and injectable capillary vessels known in certain organs, are in so small a proportion to the non-injectable substance, that it is difficult to conceive how their nutrition could occur without there existing circulating

passages, more extended and more multiplied, than those of the known blood vessels.

J. Blenland* has added to these reasons an anatomical experiment, which, if it were repeated and confirmed, would furnish the most powerful argument in favour of the existence of serous vessels.

It is known that the red injection, which is fine and very penetrating, easily passes from the arteries into the veins through the intermediate capillary vessels. It is equally known, that colouring matter remains in the capillaries, even whilst its vehicle transudes and is infiltrated in the surrounding substance, where, from the want of colour, it is impossible to discern any form or any particular direction in the passages or reservoirs into which the injection has made its escape. Blenland formed the idea of combining with the red colouring matter another white matter, which instead of being pulverulent and suspended in the vehicle, was dissolved in it. Having pushed his injection into the arteries of a part of the intestine, of which the vessels were previously filled with a coarser matter and of another colour, and having afterwards separated the peritoneal coat from the intestine, he observed in the external surface of that membrane, by the aid of the microscope, besides the capillary blood-vessels, which were all filled with red matter, another order of finer and white vessels, arising from the smallest arteries which had admitted the red injection, and entirely different from the vessels which are filled by ordinary injection.

But what are these white microscopical vascula or very minute vessels, seen but once, and on a portion of membrane detached from the neighbouring parts? Are they exhalent arterioles, opening at the surface of the peritoneum? Are they serous arterioles continuous with serous radicles of veins, and constituting a serous capillary system? Finally, are they lymphatic arterioles, continuous with radicles of lymphatic vessels? It is

* *Experimentum anatomicum, quo arteriolarum lymphaticarum existentia probabiliter adstruitur, institutum, descriptum, et icone illustratum.* Lugd. Bat. 1784, 4to.

almost impossible to solve these questions. Were they not rather accidental passages?

Those who have since admitted the existence of serous vessels, appear to have been ignorant of this, being the most powerful fact in favour of their opinion. Those who have rejected them, have also passed it over in silence.

The opinion of Mascagni, Prochaska, and others, respecting the non-existence of vessels finer than those which give passage to a single coloured globule of blood, may be established, first, upon the circumstance, that these vessels are easily seen by the aid of the microscope in living animals, and by no means smaller vessels, although the microscope gives so large a volume to the globules of the blood, that it would be easy to distinguish much smaller objects; secondly, upon the circumstance that the red injection, which is very penetrating, does not clearly disclose any other vessels than those which are seen in the living subject. If in this case the parts become more red, especially after desiccation, it may be owing to the dilatation of the vessels, and to the disappearance of the intermediate substance. If inflammation reddens the parts still more, it is by the dilitation of the existing vessels, the formation of new ones, and the infiltration of blood between the vessels. As to the whiteness or natural want of colour of certain very vascular parts, as the conjunctiva, it depends upon the circumstance, that the capillary vessels being in these parts extremely small, the colour of the blood can not be perceived in them.

§ 388. The question, therefore, which relates to the existence of the colourless capillary or serous vessels, is very difficult or impossible to answer; and when this expression is used in the present work, it is to designate capillary vessels which, whether they contain only the serum of the blood, or the blood in its entire state, but in series of single globules, which prevents its colour from being perceived, are colourless in the ordinary state. It is more consistent however with reason not to admit the existence of vessels which no one has ever seen.

§ 389. In the double circle of the circulation, the evident communication of the arterial and venous trunks occur in the

heart, and that of the lymphatic trunks with the venous trunks near that organ, in the subclavian veins. But in the points diametrically opposite to this double circle, in the capillary system, the communication is not so obvious. The ancients supposed that of the arteries with the veins, but did not believe the communication to be direct. The discovery of the circulation of the blood, while it made this communication to be necessarily admitted, still left its mode undecided. We have already seen, that microscopical observations and injections agree in demonstrating this communication, and even showing that it is direct.

Microscopical observations have demonstrated* it in the transparent parts of cold blooded oviparous animals, in the incubated egg of birds, and even in the transparent parts of mammiferous animals.

Injection has demonstrated it in almost every part of the body of man and animals,† either by forcing the matter through the arteries, or by pushing it through the veins into parts, as the intestine, in which the veins have no valves.

Some anatomists had even admitted arterio-venous communications between vessels visible to the naked eye, and of a certain calibre; thus Casserius represents them as occurring in the liver, Riolan describes them as happening after a cured aneurism, Lealis notices such communications between the spermatic arteries and veins. These are errors, that is to say, ill-observed facts, which have been contradicted by Albinus and Haller.

The communications between the arteries and veins are all capillary and microscopical, but it appears, that in cold blooded animals at least, there are some which permit several coloured globules to pass at once, and others a single one only.

The disposition of these passages of communication has been observed in animals. They consist, sometimes, simply

* Malpighi, *loc. cit.*—Leuwenhoeck. *loc. cit.*—Spallanzani, *Expéri. sur la circulation*, page 255.

† *See particularly:* Ruysch *Thes. anat.*—Winslow, *mem. de l'acad. des sciences.*—Haller, *de Fabricâ corp. humani*, vol. i.—Mascagni. *vas. lymph. &c. prodromo &c.*—Prochaska, *loc. cit.*—Reissessen, *de structurâ pulmon.*

of a change of direction or a bending of a minute artery, which becomes a venous radicle; at others a capillary artery and vein parallel to each other, also exchange communicating radicles, at the point where the artery changes into a vein; again, and frequently, several capillary arteries terminate or are continued into a single capillary vein. In all cases the communication occurs in vessels of the capacity of from one to four or five coloured globules.

§ 330. Modern physiologists have recently raised doubts respecting the direct communication of the arteries and veins. Doellinger thinks that the arteries, at their extremity, cease to have any parietes, and that the blood flows unconfined in the solid substance of the body, which he calls mucous; that at this point, one part of the blood is converted into mucous substance, and that another part of it continues its course joined to sanguified mucous substance, which is set in motion in liquid mass, and penetrates into the venous and lymphatic vessels, arising from the mucous substance as the arteries terminate in it.

Wilbrand goes still farther, and admits a still more complete metamorphosis in the circulation; according to him the whole of the blood is converted into organs, or into mucous substance and into secreted fluids, and the organs becoming fluid in the same degree, is converted again into venous fluid and lymph, which continue the circulation, and also become the matter of excretions.

According to one of these opinions, a part, and according to the other, the whole of the blood becomes solid, and likewise a part or the whole of the organs is rendered fluid at each round of the circulation. In the one as in the other, the solid mass of the body is interposed between the terminations of the arteries and the origin of the veins and lymphatics. They both suppose that the microscopical inspection of living animals and injections are deceitful means of determining the communication between the arteries and veins.

§ 391. The direct continuity of the arteries and lymphatics is not so well demonstrated as that of the veins and arteries. Many anatomists, however, have admitted, with Bartholin,

the continuity of the lymphatic vessels with the capillary arteries finer than those which allow the passage of the coloured globules of the blood. Haller, and most of the anatomists who have lived since his time, admit no other origin to the lymphatic vessels than the tegumentary membranes. Some authors, among whom is Mascagni, in admitting that lymphatic vessels likewise arise from the parietes of blood vessels, thus indirectly admit a communication, although they reject a direct continuation.

The inspection of living animals discloses nothing respecting this communication. Injections sometimes pass, and even frequently, but ordinarily colourless, from the arteries into the lymphatic vessels; which may depend on the transudation in the cellular substance, and on the passage into the lymphatics, which arise from it; or on the passage of the minute arteries into the lymphatic vessels of their parietes admitted by Mascagni, as well as upon a direct and immediate communication, which consequently remains very doubtful.

§ 392. The serous capillary vessels which have been admitted beyond the capillary blood vessels, much more from physiological considerations, than from positive anatomical demonstration, is not the only hypothesis of this kind. Absorption and secretion being certain and evident facts, as already announced by the father of medicine,* many have been the researches in order to find, by what passages substances issue from the vascular system, and by what passages they enter it. Without ever having seen them, they have been described, the one under the name of exhalent or secretory vessels, the other under that of absorbent or inhalent vessels.

The exhalent vessels have been admitted by Haller, Hewson, Sœmmering, Bichat, Chaussier, &c. as being very simple vessels, appearing to be very minute and short productions of the capillary arteries, and diffused in the tegumentary and serous membranes, and the cellular tissue.

Other anatomists, such as Mascagni, Prochaska, and Riche-

* Δῆλου, ἢ αἴσθησης, ὡς εκπνοον, καὶ εἴσπνοον ὅλον το σωμα. *Epedem*. bib. vi. sect. vi.

rand, admit, on the contrary, the opinion that it is by lateral pores, organically arranged, that secretion or exhalation occurs.

Hunter had even admitted that it was by pores or inorganic interstices that secretion took place, precisely in the same manner as transudation in the dead body. Hewson and Bichat have controverted this opinion.

The real passages, however, of exhalation or secretion are entirely unknown. All we know on this subject, is merely this, that in the living body, fluids issue under the form of vapour from all points of the capillary system; and that several are observed in a liquid form, or even more or less concrete; while in the dead body fine injections, in passing from the arteries into the veins, ooze out on the surface of the skin and mucous membrane, in the mucous and cutaneous follicles, in the excretory ducts of the glands, on the free surface of the serous membranes, and in the mucous, areolar or cellular substance, which constitutes the solid mass of the body; but never, and nowhere are there seen ramuscules arising from capillary net-works and terminating by an open extremity. The passages of exhalation or secretion are therefore unknown. It is very probable that it occurs through the solid and porous substance of the body. Secretion, however, is an organic or vital phenomenon entirely different from transudation in the dead body, as is demonstrated by the difference which the various secreted humours present, and the differences of quantity of these humours. The names of exhaling or secreting vessels can only therefore, designate the unknown passages through which the molicules, formed by the matter of the intrinsic and extrinsic secretions, issue from the circulation.

§ 393. Nearly the same may be said respecting the passages or mechanism of absorption. The absorbent vessels, according to the idea entertained of them, are radicles open at one extremity, similar to the puncta lachrymalia, and continuous at the other, either with the venous and lymphatic net-work, or with the lymphatic vessels alone, or with the veins alone, of which they are thus the origin. Now, neither these canals

nor their patelous mouths have ever been seen. The following are the opinions and facts known with respect to this nice point of anatomy. Aselli has said, with reference to the lacteal or chyliferous vessels: "*ad intestina instar hirudinum orificia horum vasorum hiant spongiosis capitulis.*" Helvetius asserts that the intestinal villosities have spongy orifices. Lieberkühn speaks of a spongy or cellular ampulla. Hewson rejects the belief in this ampulla. Cruikshank describes and figures twenty or thirty openings, each larger than a globule of blood at the summit of each villosity. Sheldon makes the villosities terminate by a spongy tissue, and appears to confound the follicles with them. Mascagni could see no orifices at the summit of the villosities. Feller and Werner describe an ampulla, and trace vessels into it. Bleuland admits openings at the summit of the villosities. Sœmmerring observes that from six to ten absorbent orifices may be seen in each of them. Hedwig considers the ampulla as spongy, and describes their summit as having one orifice or more, or none Rudolphi has never seen any orifices, and those which have been admitted seem to him to depend on optical illusions. This is quite sufficient in order to conclude, that the orifices which have been described do not distinctly exist. We must add, however, that when a very penetrating injection is thrown into the intestinal veins, the matter in passing into the arteries, transudes also at the free surface of the mucous membrane. It is known with respect to the skin, that when a lymphatic vessel of that membrane has been injected, if the mercury be pushed back towards the roots of the vessels, it at length issues from its free surface, as remarked by Haas. Mascagni has made this experiment, and any person may easily repeat it, on the sub-peritoneal lymphatic vessels of the liver. Finally, Carlisle asserts that he has seen orifices of lymphatic vessels in a cell of the cellular tissue.

However doubtful and contradictory the facts may be, the following is the opinion generally admitted, namely, that at the surface of the tegumentary and serous membranes, in the areolæ of the cellular tissue, and according to Mascagni, at the very surface of the vessels, there are orifices of absorbent radi-

cles leading, according to the greater number of modern writers, into the lymphatic vessels only, but according to the anatomists anterior to Haller, and some more modern than him, into the veins only; and according to others, both into the capillary blood-vessels and lymphatics. Prochaska adds to this, among the passages of absorption, the organic porosities of the vessels, which would thus be, at once, the passages of exhalation and inhalation. Absorption has also been considered as a purely physical phenomenon, comparable to capillary attraction or imbibition, by adducing in support of it, the absorption which occurs in the dead body.

The fact is that the passages of inhalation are unknown. They appear to be like those of exhalation, the porosities of the solid and permeable substance of the body. Absorption, however, like secretion, is an organic and vital phenomenon altogether different from imbibition in the dead body, as is demonstrated by the selection of the substances absorbed, and by the modifications which the activity of absorption presents in various cases. When, in this work, the term absorbents is used, it is to designate by a single word the unknown passages by which foreign substances enter, and those by which the matters of the intrinsic absorptions pass into the circulatory apparatus.*

§ 394. Imagination has not stopped at the creation of exhalent and inhalent vessels, of which we have been speaking; nutritive vessels have been also supposed.

The following are the principal opinions entertained on this subject. Boerhaave and R. Vieussens having admitted colourless and decreasing vessels, the former conceived the body entirely constructed of vessels, even those parts which can not be injected. According to Boerhaave's system, the smallest elementary fibres form minute membranes, rolled upon themselves, to constitute the smallest nervous vessels. From these smaller vessels result the vascular membranes forming larger vessels, and so on to the largest ones. He also determined

* See experiments on Edosmose and Exosmose in the No. 7 of the American Journal of Med. Sciences. TRANS.

that the smallest nervous vessels contain an aqueous fluid, serving for feeling, motion, and at the same time nutrition.

The opinion of Mascagni as to the elementary composition and nutrition of the parts, does not differ much from that of Boerhaave. According to Mascagni, the division of the arteries finishes at the point where, or having arrived at the tenuity of a red globule of blood, they are converted into veins. There, they are furnished with exhalent porosities, as well for the secretions as for nutrition. In all parts there are orifices of absorbent vessels for taking up and containing the nutritive molecules. The elementary parts consist of absorbent vessels: these, by their union, constitute the most simple membranes and the smallest blood vessels, which form the most compound membranes.

In these two hypothesis, every thing is vascular, and nutrition happens in the vessels; in the first, in the finest ramifications of the capillary arteries, in the second, in the finest radicles of the absorbents. In both, the vessels constitute the mass of the body, and are truly in a continual state of circulation.

Bichat's opinion respecting the nutritious vessels and nutrition, is somewhat different. According to this author, each molecule of the organs is in a manner placed between two patulous vessels; the one a nutritive exhalent which had deposited it, and the other a nutritive absorbent, destined to take it up again.

Prochaska, while he admits the direct communication between the arteries and veins, supposes that it is by the porosities of the parietes of the vessels and the general permeability of the substance which forms the mass of the body, that nutrition occurs.

§ 395. Nutrition, whatever may be its immediate channel, presents a continual two fold motion of composition and decomposition. The simplest animals directly inhale and exhale the materials of this double phenomenon. Other animals, of a more complex organization, have a tegument more or less prolonged into the mass of the body, conveying there and taking up again the matters which are added to it, and those which are separated from it. Others, still more complex, have

other organs, vessels, which transport from the surfaces into all parts of the mass, and hence back to the surfaces, the matters of absorption and secretion. In certain animals provided with vessels, among which is man, their number is so great, that they seem to occupy and form the whole mass of the body. But, besides the above considerations, which are derived from analogy, the arguments derived from inspection also show that the vessels only traverse the mass of the body, and do not constitute it. Observation also shows that, whatever may be the tenuity or softness of the last capillary vessels, the arteries and veins form continuous canals.

Observation teaches us, that new substances enter into the vessels, and that others also unceasingly issue from them. But this two-fold passage takes place in the finest parts of the vessels, and by paths invisible even with the best optical instruments; the substances themselves circulate through these passages in a state of division, in vapour, which eludes the senses, and is imperceptible with the best microscopes. This passage, whether it occurs from without inward, or from within outward, in extrinsic absorptions and secretions, or whether it takes place in the closed cavities of the body, always appears to be performed through the intervention of the solid and permeable substance of the body; that is to say, of the substance called cellular, which, by imbibing, transmits inwards or outwards the inhaled or exhaled molecules.

The same appears to be the case with respect to nutrition. The vessels deposit and take up under the form of vapour, and by invisible passages, in the cellular substance, the molecules of the composition and decomposition of the organs.

But all these phenomena, which are apparently physical, are modified by the organized and living body in which they occur. It is especially to the unknown cause of these phenomena, that the name of vital power has been given, or more particularly, that of power of formation.

II. OF THE ERECTILE TISSUE.

§ 396. The erectile, cavernous or spongy tissue, consists of terminations of blood vessels, and especially of the radicles

of veins, which, instead of being capillary, have more width, are very extensible, and are connected with numerous nervous filaments.

§ 397. This tissue was first observed in the penis, where its dimensions are very considerable. Vesalius* speaks of it in these terms: *corpora hæc (cavernosa) enata ad eum fere modum, ac si ex innumeris arteriarum venarumque fasciculis quàm tenuissimis, simulque proxime implicatis, retia quædam efformarentur, orbiculatim a nervea illa membraneaque substantia comprehensa.* Malpighi† appears to have made the same observation: *sinuum speciem in mammarum tubulis et in pene habemus; in his nonnihil sanguinis reperitur, ità ut videantur venarum diverticula, vel saltem ipsarum appendices.* Hunter‡ has seen the same thing with reference to the spongy tissue of the urethra; "It is well to remark," says he, "that the spongy body of the urethra and glans penis are not spongy or cellular, but consist of a plexus of veins. This structure, he adds is visible in the human subject, but much more distinctly in some animals, as the horse &c."

The greater part of the anatomists, however, who have examined the structure of the penis, and among other De Graaf, Ruysch, Duverney, Boerhaave, Haller and his disciples, having mistaken the nature of the cavernous and spongy tissues of the penis, and having considered them as being loose and elastic cellular tissue, forming cells, and interposed between the arteries and veins, most modern anatomists have adopted this error. Duverny, Mascagni, Cuvier, Tiedemann, Ribes, Moreschi, Panizza, Farnese, &c., have made accurate observations on the erectile tissue of the penis of the elephant, horse, man, &c., as well as on the clitoris of their females.

§ 398. Although the erectile arrangement of the vessels exist in many parts of the body, nevertheless, there is a certain numbes in which it is much more evident. These are the corpus cavernosum of the penis and clitoris, the spongy body of the

* *De corp. Hum. Fabricâ.* Lib. v. cap. 14.

† *Diss. Epist. Varii Argum. In op. omn.* vol. ii.

‡ *Observations on certain parts of the animal economy.* 4to. London, 1786.

urethra, the nymphæ, the nipple, the papillæ of the tegumentary membranes, &c.

§ 399. The erectile tissue is of very large dimensions in the organs of copulation. Though it does not present the same development in the papillæ, yet it may be very distinctly observed in them.

The papillæ, those of the tongue in particular, consist of enlarged soft nervous filaments, destitute of neurilema, intermingled with an innumerable multitude of capillary blood-vessels, tortuous, arched, and anastomosing with each other, the whole enveloped and collected together by a soft and mucous cellular tissue. In a state of rest these papillæ are small, soft, pale, and indistinct. In that of erection, on the contrary, they are enlarged, raised up, of a red colour, swollen with blood, and possessed of great sensibility.

The nipple or the papilla of the mammæ, appears to differ from the others only in being of larger dimensions. The skin and mucous membrane present the papillary and erectile dispositions in various degrees, in their whole extent. The volume of the nerves and the quantity of the blood-vessels, are every where proportionate to the degree of sensibility. The skin of the pulp of the fingers, which is very vascular and nervous, experiences a degree of swelling, and of manifest redness during the act of touching, proportionate to its perfection.

§ 400. The erectile tissue of the organs of copulation differs from that of the papillæ only in having its dimensions much larger. That of the corpus cavernosum of the penis presents the following disposition. It is enveloped by a sheath of elastic fibrous tissue, which sends prolongations into its interior. The two dorsal arteries of the penis are accompanied by an azygos vein forming a plexus, and by nerves of great size. The arteries send into the interior numerous minute branches accompanied by nerves, and the veins receive numerous radicles through the sheath. The interior is composed of arterial ramifications coming from the dorsal arteries, and central arteries, and of very numerous large veins, intermingled in all directions, and anastomosing a multitude of times with each other. These branches of veins present dilatations and wide

communications. When one of the arteries of the penis is injected, the injection, if very fine and penetrating, after filling the arterial ramifications, and the internal venous plexus, which constitutes the corpus cavernosum, and thus producing erection, returns by the dorsal vein. The corpus cavernosum is still more easily filled by injecting through the vein. Thus the pretended cells of the corpus cavernosum, are merely very large roots of veins forming a complicated plexus, and anastomosing like capillary vessels.

The erectile tissue of the urethra and glans have the same disposition; the same is the case with respect to that of the clitoris and nymphæ.

Erection, in the organs of copulation as in the papillæ, is produced by the repletion of the erectile vessels. This repletion may depend on the afflux of arterial blood, which is accompanied by an exaltation of the sensibility, and the retention of the venous blood, or by both causes united.

§ 401. There is still a part whose texture and phenomena greatly resemble those of the erectile organs: this is the spleen, which, by this means, seems to be a diverticulum of the blood. If the spleen be exposed in a living animal, and the course of the blood in the splenic vein be arrested by pressure, this organ swells and greatly augments in size; but it quickly assumes its natural appearance as soon as the circulation is re-established. The accessions of intermittent fever are accompanied, during the chill, by a manifest swelling of this organ, which is more or less completely dissipated when the accession is at an end. It would appear that the same thing takes place during digestion.

§ 402. The erectile tissue is sometimes accidentally developed in the organism. This production has been described under the names of varicose tumour, aneurism by anastomosis, aneurism of the smaller arteries, telangiectasis, &c.

Its anatomical characters are precisely the same as those of the natural erectile tissue. It is a more or less voluminous, or more or less circumscribed mass, sometimes surrounded by a thin fibrous envelope, presenting internally an appearance of cells or spongy cavities, consisting in reality of an inextricable

net-work of arteries and veins, which communicate by innumerable anastomoses, like the capillary vessels, but much wider, especially the veins, easily injectable by the neighbouring veins, which are sometimes varicose, but with difficulty by the arteries.

This alteration most commonly exists in the substance of the skin, and to a greater or less extent. It then sometimes resembles the crest and other similar parts of the gallinaceous birds. The skin of the face, and especially that of the lips, is frequently the seat of this alteration. It is observed in the subcutaneous cellular tissue, or more or less deep; it has been seen occupying a whole member; it is even asserted to have been observed in some viscera.

This production is the seat of a vibration, a rustling, and a pulsation, more or less manifest, and which are increased by all the causes which excite the activity of the general circulation; but the tumours which it forms, even in the skin, are by no means susceptible of a kind of isolated erection. It is most commonly congenital, and at other times appears to depend on an accidental cause; it sometimes continues without change, at others, which is the most common case, it augments continually in size by the dilatation of its internal cavities, and at length bursts, giving rise to hæmorrhages, which are difficult to repress.

Around the arms there occur hemorrhoidal tumours, resembling the spleen in appearance, which constitute a variety of this accidental erectile tissue.

III. OF THE VASCULAR GANGLIA.

§ 403. The vascular ganglia, adenoid or glandiform organs, or aporic glands,* confounded under the common name of glands with organs of excretory secretion, are also parts in

* Queitschius, *De glandulis coecis, &c. in select. med. Francof.*—Hendy, *Essay on glandular secretion.*—Hewson, *Descriptio glandul. &c. opus posthum in op. omn.*—H. F. F. Leonhardi, *De glandulis in genere et glandulis aporicis, &c.*—Dresden, 1813.

which the termination and communications of the vessels affect particular dispositions. Hensinger has given to them the name of parenchymatous tissue.

Their texture results from the union of several other tissues. They are formed of modified cellular tissue, of blood vessels and lymphatics, and of nerves; the whole inclosed in an envelope, which send prolongations into the interior. They are all situated in the course of the lymphatic and venous circulation, and seem to be destined to make the absorbed substances undergo an elaboration, and to prepare their assimilation; they thus appear to be in a kind of antagonism to the true glands or the organs of excretion. The vascular ganglia differ from each other in the quantity and the species of tissue of which their mass is formed, in the proportion of vessels and nerves, and in the mode of communication of the vessels.

§ 404. The adenoid ganglia may be distinguished into two kinds: 1st, the lymphatic glands or ganglia; and 2dly, the ganglia of the blood vessels, which are the thyroid gland, the thymus, the surrenal capsules, and the spleen.

The former of these will be described along with the lymphatic vessels, (*sect.* iv.) The others, which form a less natural group, belong principally to special anatomy. They have, however, some general characters. The ganglions of the blood vessels* are larger and much less numerous than the lymphatic ganglia. They are of a brownish-red colour, globular and granular. They present internally distinct cavities, filled with a fluid, but little ramified and closed on all sides. It was believed, at divers epochs, that excretory ducts had been discovered in them, but these supposed discoveries have not been confirmed. These ganglia are so intimately connected with the blood vessels and lymphatics, and especially with the thoracic duct, that they have been supposed, with

* Boeckler, *de Functionibus glandulæ thyreoidæ, thymi, atque glandul. supraren., &c.* Argentor. 1753.—Hecker, *über die verrichtung der kleinsten schlagaden und einger ans einem gewebe der feinsten gefasse bestehenden eingeweide, der schild-und brust-drüse, der milzes, der nebennieren und nachgeburt.* Erfurt, 1790.

much probability, to have a very great influence upon the perfecting of the lymph and chyle, and on the formation of the blood.

SECTION II.

OF THE ARTERIES.

§ 405. The arteries,* *arteriæ*, are the vessels which convey the blood from the heart to all the parts of the body.

§ 406. Hippocrates and his contemporaries gave the name of veins to all the vessels and canals, with the exception of the trachea, which they called artery. Aristotle is the first who speaks of the aorta, which he names the small vein. Praxagoras gives the name of artery to the aorta and its branches, which he believed to contain a vapour. The school of Alexandria distinguishes the arteries from the veins by the thickness of the walls, and admits that the blood may, under certain circumstances, pass into the arteries. Galen, the greatest anatomist of antiquity, tries to prove that the arteries are full of blood in their natural state. He considers the venous system and the arterial system each a tree, whose roots, implanted in the lungs, and whose branches, distributed throughout the body, meet at the heart. It was not until Vesalius, that the first rudiments of the art of injecting the blood vessels were known, and it was not until his day that some notions respecting the texture of the blood vessels are to be found. Their functions and alterations have only been known in later times.

§ 407. There are two arterial trunks; the aorta and the pulmonary artery, both have an arborescent disposition, and pre-

* Bassuel, *nouvel aspect de l'intérieur des artères, et de leur structure par rapport au cours du sang; mém. présent. de math. et de phys.* tom. I. ann. 1750.—D. Belmas, *structure des artères, leurs propriétés, leurs fonctions et leurs altérations organiques. in* 4to. Strasbourg, 1822.—Ch. H. Ehrmann, the same title, place and date.

sent an origin, a trunk, branches, twigs, and ramusculi, becoming smaller and smaller until they reach their termination.

Each of the arterial trunks arises from a ventricle of the heart, and does not present here a continuation of the substance of the heart, as has even recently been advanced, but an intimate and very remarkable connexion of the middle membrane of the artery is divided into three festoons, bordered with ligamentous tissue, the orifice of the ventricle is furnished with a ring of the same tissue, the extremity of the festoons of the artery is firmly fixed to the orifice of the ventricle, and the triangular intervals of the dentations are likewise occupied by ligamentous membranes; the internal membrane of the vessel is continuous with that of the heart, and the external membrane is united to the substance of that organ.

The trunks, the branches and all the divisions of the arteries are obviously cylindrical. There are nevertheless exceptions; some arteries enlarge as they advance, while others seem to contract. The arterial cylinders gradually diminish from the trunks even to the last ramifications.

Generally the sum of the calibre of the branches is greater than their main trunk, but to this there are exceptions; thus it is not evident, that the carotid and brachial arteries have together a greater capacity than the trunk of the innominata; neither is it certain, that the radial and cubital arteries united, have a greater capacity than the brachial. We must not confound, in this comparison, the external diameter with the capacity. Besides it very often happens, that the capacity of the arterial branches changes, without an appreciable change in their size; and to cite only an obvious example of it, the uterine arteries augment considerably during pregnancy, while the hypogastric artery which furnishes them, increases but little, and the primitive iliac artery not in an appreciable manner.

The variable number of the successive divisions of the arteries, their mode of division, and the angles which are found between the branches and the trunks, have been indicated [354, &c.] as well as the anastomoses and the lateral passages

that they present to the circulation. The same is the case with their flexuosities.

The termination of the arteries, when they become capillary and microscopic, occurs by their being continued into veins, either by red capillary communications, or by communications of colourless vessels in consequence of their extreme minuteness.

§ 408. The arteries are cylindrical when examined internally, their section is circular, excepting in the largest arteries, which, when empty, are slightly depressed, and present an elliptic section.

Each of the two arterial trunks is furnished with three valves at its origin in the heart. These semi-lunar valves are attached by their convex edge to the contour of the festoons of the artery; their free margin is straight and somewhat thick, especially at the middle, which present a small enlargement. One face is turned toward the parietes of the artery, and the other towards the axis of the vessel. These valves are formed by the inner membrane of the arteries, doubled on itself, and containing in its substance a thin layer of ligamentous or fibrous tissue; their free margin contains a small cord of this tissue, and its middle a fibro-cartilaginous point. When these valves fall, the face, which corresponds to the ventricle, becomes convex, and the other, which corresponds to the canal, becomes concave; their free edges meet, touch each other, and they exactly close the vessel. In all the rest of their extent the arteries are deprived of valves.

The internal surface is smooth, polished, and moistened. The external surface corresponds to the common and particular cellular tissue in which the arteries ramify. The cellular tissue moulded around them, or separated by their presence, forms a cellular sheath for them. This sheath is confounded externally with the rest of the cellular tissue, or with the substance of the organs; internally it is united to the artery in so loose a manner, as to permit the latter to slide easily in its interior during the different motions, and to retire within it by contracting in the longitudinal direction when it is divided This sheath is pretty firm around the arteries of the limbs; in the thorax and

abdomen the sheath of the arteries is in part formed by the serous membranes. That of the spermatic arteries is remarkable for its looseness, and that of the arteries of the brain is not distinct. This part of the anatomy of the arteries, deserves particular consideration in pathology, and in performing operations.

§ 409. The texture of the arteries* results from several super-imposed membranous layers. There has been much diversity of opinion with reference to their number, it being supposed to be, even as far as five by some anatomists, and reduced to one by others. It may be fixed at three, namely: an outer, a middle, and an inner.

§ 410. The external membrane, called also, cellular, nervous, fibrous, &c., is thin, and of a whitish colour, and formed of oblique and crossed fibres, interlaced diagonally with reference to the length of the vessel. Externally this tissue is rather loose, and adheres to the sheath; internally, on the contrary, the little fibres are so close that they can only be perceived on tearing them asunder. In the arterial trunks, this two-fold disposition is so distinct, that the outer layer really appears double; in the middle sized and small arteries, on the contrary, this layer becomes uniformly close and distinct from the cellular tissue of the sheath, and then greatly resembles the ligamentous tissue.

This membrane is very tough and very elastic, both in its longitudinal and circular direction. Supple and possessing great strength at the same time, it is not divided by the action of ligatures, even when directly applied to it. When we attempt to tear it, great difficulty is experienced, and the texture of its oblique fibres is perceived, which render its tenacity equal in all directions.

§ 411. The middle membrane, called also muscular, ten-

* Ludwig, *de Arteriarum tunicis*, Lips. 1739.—Albinus, *acad. annot.* lib. iv. Cap. viii. *de arteriæ membranis et vasis.*—A. Monro, *Remarks on the coats of arteries, their diseases, &c., in his works.*—Delasone, *sur la structure des arteres, mém. de l'acad. des sci.* 1756.—C. Mondini, *de Arteriarum tunicis, in opusculis scientifici* t. i. Bologna, 1817.—A. Béclard, *sur les Blessures des arteres, Mém. de la soci. méd. d'emulation*, t. viii. Paris, 1817.

dinous, proper membrane, &c. is thick and of a yellowish colour, and is formed of nearly circular or annular fibres. This membrane, the thickest of the three, is very apparent in the trunks; it augments proportionally in thickness, as the arteries diminish in volume. Its thickness is inconsiderable in the arteries of certain viscera, and particularly in the arteries of the brain. It can be divided into several layers by dissection; this, probably, has led into error those who have admitted more than three arterial membranes. The external fibres are less close, the deeper seated still more so, and thus progressively. These fibres do not all encircle the vessel. The longitudinal and spiral fibres which have been admitted in the middle membrane, do not exist. In the places where the arteries divide, the circular fibres of the trunk separate and form on each side a half ring, and the annular fibres of the branches succeed these latter. The middle membrane is intimately united to the outer one.

The middle membrane has so great a degree of strength, that when detached from the others it retains its cylindrical form; it is to it that the arteries owe the faculty of remaining open when they are empty. When isolated, it possesses a feeble power of resistance and elasticity, in the longitudinal direction of the arteries, but is very tenacious and elastic in the direction of its fibres, *i. e.* in that of the circumference of the vessel. The firmness and elasticity of the fibres, which form it, successively diminish from the large towards the small arteries. It has been, by turns, compared and likened to the muscular fibre in general, the muscular fibre of the uterus, and the fibrous or ligamentous tissue; it constitutes a species of elastic tissue, a peculiar tissue, but participating of the characters of the muscular and ligamentous fibres.

§ 412. The inner membrane of the arteries, which is also named the nervous, arachnoid, common, &c. is the thinnest of the three. It is continued from the ventricles of the heart into the arteries; by it the greater part of the semi-lunar valves of the arteries are formed. In the larger branches, when empty, it presents some longitudinal folds, and small transverse ones in the arteries of the ham and elbow-joint; it is equally wrin-

kled in the retracted arteries after amputation. Its inner surface is smooth, polished, moist, and in contact with the blood; its outer surface adheres to the middle membrane. In the arterial trunk, it can be divided into several layers. The innermost is extremely thin, and transparent; the others are of an opaque white, and passes insensibly into the middle membrane; it is to this part especially, that the name of nervous membrane has been given. In the branches, it forms only a single indivisible lamina. No appearance of fibres is distinguished in this membrane, which is very dense; it tears nearly with the same facility in all directions. It has little elasticity. It has been compared to the serous membrane and the mucous or cellular tissue. It is not vascular like the serous membrane generally; and it is to the arachnoid membrane that it bears the greatest resemblance.

§ 413. Cellular tissue, vessels and nerves, also enter into the composition of the arteries.

The cellular tissue which penetrates into the outer membrane, and which unites it to the middle one, is sufficiently apparent, but beyond this, it is so rare and compact, that its existence has been doubted. However, when by dissection the outer membrane, and the greater part of the thickness of the middle one are removed from an artery, there spring from the uncovered part fleshy granulations, as from the remainder of the wound.

§ 414. The arteries and veins of the arteries (*vasa arteriarum,*) are furnished by the neighbouring vessels, and become very apparent in the outer membrane by injections, and even sometimes without them, particularly in young subjects. They have been traced to their entrance into the middle membrane, but no farther.

What are called exhalent and absorbent vessels, or more correctly the unknown passages of exhalation and inhalation, are demonstrated in the parietes of the arteries by the fact itself, for in inflammation of the arteries an exhalation occurs at their internal surface; and, in cases of ligatures, the internal coagulum is absorbed.

§ 415. The nerves* of the arteries are derived from the spinal marrow and the ganglia. The arteries of the organs of the vegetative functions receive theirs from the ganglia, the others from the spinal marrow. The nerves of the arteries form around them a net-work analogous to those which the pneumogastric nerves form around the œsaphagus, and thus accompany them into the interior of the organs. But, moreover, some filaments terminate in the outer layer, and others reach the middle membrane, on which they spread out into a very delicate net-work. The former are soft and flat, the latter, which are filiform and of extreme minuteness, have more consistence, and pass through a shorter course. All the arteries do not receive an equal number of nerves; the pulmonary arteries receive fewer than the aorta and its divisions. The smaller the arteries are, the more abundant are the nerves. The arteries of the brain are furnished with nerves only to the place where they penetrate into the cerebral substance. In old age, the nerves of the arteries, especially those of the middle membrane, become less apparent. The great number of nerves which are distributed to the arteries, shows that a close connexion exists between the nervous system and the circulatory apparatus, or between the nerves and the blood.

§ 416. The most physical properties of the arteries are the toughness of their tissue, its tenacity and elasticity. It is to the firmness of the middle membrane that they especially owe the power of preserving a considerable part of their tubular form, even when empty of blood. Their specific gravity is about 108. Their thickness, which is generally considerable, is a little augmented when they are empty. It is also somewhat greater on the convex side of the curvatures than on the opposite side, being nearly in the proportion of 8 to 7. It increases proportionally to the caliber of the arteries in the same degree as the latter diminishes; it is not the same, however, in all the arteries of the same diameter; thus the parietes of the arteries of the brain are very thin, and those of the limbs are thick.

* A. Wrisberg, *loc. cit.*—Lucæ, *quadam observ. anat. circa Nervos arterias adenutes et comitantes.* 4to *cum fig.* Francof. ad Moenum, 1810.

§ 417. Clifton Wintringham has examined the tenacity of the arteries and the resistance they oppose to rupture. I have also made some experiments on this subject. These vessels have a great power of resistance, which is, generally, in proportion to their thickness. That of the aorta is superior to that of the pulmonary artery. In the same degree as the arteries diminish in size, their absolute tenacity diminishes, but their relative thickness and softness increase, their extensibility and relative resistance augment. The resistance is not, however, the same in all the arteries of the same volume: that of the iliac artery is greater than that of the carotid. The tenacity in the longitudinal direction is almost entirely owing to the outer membrane. The circular resistance, which is much stronger, is owing to the middle and outer layers. The inner membrane has very little power of resistance in either direction.

§ 418. The most important physical property of the arteries is their elasticity. If they be distended in the longitudinal direction, they yield and elongate, to return suddenly to their former state whenever the distention ceases. If they be distended transversely, they are less distensible and spring back with greater force. If by injection or insufflation they are distended to excess, they enlarge a little, elongate, and when the effort ceases, they spring back upon themselves and expel part of their contents. If they be bent, they return to their former direction; if they be flattened by pressure, they resume their cylindrical form. During life, they are in a state of elastic tension, which, when they are divided, causes the ends to retract.

The largest arteries possess a very distinct elasticity, but it diminishes successively in the smaller ones.

§ 419. The arteries are also susceptible of a slow extensibility and retractibility. When a principal artery is obliterated, the collateral arteries, in replacing it in its functions, enlarge and acquire, in a short time, a considerable volume; this enlargement is of the same kind as ordinary growth, but is much more rapid; the artery, on the contrary, which ceases to af-

ford a passage to the blood, gradually shrinks, and ultimately disappears more or less completely.

§ 420. The vital properties of the arteries, like those of the other parts, are relative both to their own nutrition and to their action in the organism. The force of formation is manifest in them by their accidental productions, and less in the reparation of their lessions. Irritability is susceptible to a certain degree; sensibility is much less obvious.

§ 421. Arterial irritability,* called also tonicity, contractility, vital force of the arteries, power of contraction, or the force by which the parietes of the arteries, during life, draw towards its axis without even having distended, has been a subject of great controversy among physiologists.

Haller, who admits that the middle coat of arteries is of a muscular nature, confesses that his experiments have taught him nothing positive on their contractility, and that these vessels have not always given evidence of the effects produced on them by chemical and mechanical stimulants. Bichat, Nysten, and Magendie, have all denied the irritability of the arteries. Bichat founds his opinion on the circumstance, that mechanical irritation within or without the vessel does not produce motion; if an artery be open lengthwise, its edges do not curl; if it be separated from the body, it evinces no mark of contractility; if it be dissected layer by layer, its fibres are not perceived to palpitate; if the finger be introduced into an artery during life, it is not firmly grasped by it; if an artery be intercepted between two ligatures, it experiences only a motion communicated to it. The contraction produced by acids, is a horny induration, and the action of alkalies is next to nothing.

The greater number of anatomists and physiologists, however, are of a contrary opinion, founding it on a great number of facts. Verschuir and Hastings have observed mechanical

* *See* Chr. Kramp, *de vi vitali arteriarum.* Argent, 1785.—C. H. Parry, *An exper. inquiry into the pulse and other prop. of arteries, &c.* Bath, 1816. —Ch. H. Parry, *Additional experi. on the arteries, &c.* Lond. 1819.—Hastings, *loc. cit.*

irritation to produce the contraction of the arteries. Zimmermann, Parry, Verschuir, and Hastings have remarked that mineral and vegetable acids cause the same effect. Thomson and Hastings have seen the same thing occur by the action of ammonia. Verschuir, Hunter, and Hastings have observed the simple action of the air and of temperature to produce this contraction. Hastings has also obtained the same result by the application of oil of turpentine, the tincture of cantharides, the solution of muriate of ammonia, and of sulphate of copper. Bikker and Van den Bosch have caused the contraction of the arteries by electricity; Guilo and Rossi by galvanism; Home has observed it even on the application of an alkali on the nerve adjoining an artery. Vital contractility, little appreciable in the larger arteries, augments successively in the smaller ones.

We may also cite as a farther proof of the existence of the irritability of the arteries, the augmentation of their contraction in inflammation and in neurosis. Thus, in panaris, in angina tonsillaris, in tic douloureux, &c.; we see and feel the arteries beat on one side much more than on the other. We sometimes observe differences of the same kind in hemiplegia. The same thing also occurs in pregnancy, and in many other hygid or morbid phenomena, accompanied with a local development of vessels.

We may therefore conclude, from what proceeds, that during life the arteries possess both elasticity and irritability; that elasticity predominates in the large, and irritability in the small arteries; that arterial irritability is more or less dependent upon the nervous influence. In the course of time, the *vasa vasorum* diminishing, the nerves of the arteries gradually disappearing, and the middle membrane becoming harder, the arterial irritability lessens more and more, and even the elasticity itself is greatly impaired.

§ 422. The sensibility of the arteries is null or extremely obscure. Verschuir relates one single experiment in which an animal seemed to feel pain on the application of a mineral acid. According to Bichat, on injecting an irritating liquid a lively pain appears also to be produced.

§ 423. The function of the arteries is to convey the blood from the heart to all the parts of the body. When the ventricles of the heart propel, while contracting, a new supply of liquid into the arteries, already full with blood in motion, the velocity of the motion is increased in all the arteries: the observation of the wound of an artery proves it. Another effect of the systole of the ventricles, generally admitted, is the dilatation of the arteries. Experiments have been cited in support of this dilatation; other interesting experiments of Doctor Parry appear to contradict it; it really exists, however, but it is very inconsiderable. Another effect, but more appreciable, produced by each systole, is the elongation of the arteries. The action exercised by the arteries in order to send forward the blood, is their elastic return on themselves, which narrows and shortens them, and consequently diminishes their capacity, and moreover, a force of vital contraction which is added to elasticity in the middle sized arteries, and this vital contraction exists exclusively in the small. The velocity of the course of the arterial blood generally diminishes from the trunks to the last ramifications; this velocity presents besides local varieties, either permanent or accidental.

The function of the arteries is therefore to convey, like canals, the blood in all the parts of the body, and like contractile canals, to communicate to it a part of the motion with which it is animated. The action of the arteries on the blood has been at times exaggerated and at others too little appreciated. It is very certain, 1st, that the vessels appear before the heart, both in the animal series and embryo; 2d, that the monstrous fœtus without a head is deprived of a heart; 3d, that in fishes there is no aortic ventricle, and that even in man the vena portarum (*sect.* iii.) is equally deprived of a muscular agent calculated to communicate an impulsion; 4th, that in the reptiles from which the heart has been removed, the motion of the blood continues for a long time. All these facts evidently prove that the vessels are an agent, and are even the primitive agent of the motion of the blood. The arteries participate in this movement by their elasticity and irritability

But it is no less certain, that in animals provided with a

heart, this organ becomes a powerful agent of the movement of the blood; it is thus, that by its own action the arterial circulation, although continuous, is pulsatory; it is thus that the circulation takes place in the sturgeon, although the aorta is inclosed in a bony canal; in the same manner in man, the aorta and its principal branches may be ossified without materially impairing the regularity of the course of the blood. We must hence conclude that both these powers (that of the heart and that of the arteries,) contribute to the performance of the circulation, and that one may in a measure supply the action of the other. But the action of the heart on the blood gradually diminishes, and that of the vessels augments, in proportion as it is more distant from the centre of circulation. The vital contraction of the arteries is also one of the causes of their emptiness in the dead body.*

§ 424. The arterial circulation is accompanied with a movement called pulse. At different times it was ascribed to the alternate dilatation and contraction of the arteries; to the elongation of these vessels, and to the motion which results from it; to the pressure of the finger while feeling it, or to several of these causes combined. The number of pulsations depend solely upon that of the contraction of the heart. The volume or fullness of the pulse is owing to the quantity of the blood contained in the arteries; its duration, to that of the contractions of the heart; its strength, to the quantity of the blood propelled by the heart, to the power with which it is pushed, to the quantity contained in the arteries, and to that which passes through the capillary vessels.

The feeling of the pulse has for its object the examination of the state of the circulation, and of the powers which move the blood, viz., the heart and vessels.

* With all due deference for the opinion of our author, we beg to differ with him on this point. We believe that the new experiments on endosmose and exosmose tend to prove the contrary position. We conceive that the larger arteries have lost at this time all power of vital contract here ascribed to them, when the blood is, by an *action in the capillaries,* as yet not positively demonstrated, drawn from the larger arteries through the capillaries into the veins. TRANS.

The parietes of the arteries augment in thickness and density during the period of growth; they still continue to increase in density during the remainder of life.

The variations in the distribution of the arteries are much more frequent than is generally imagined. Bichat and Meckel* have justly remarked, that they are at least as often met with, as those of the veins, and perhaps even more frequently. It is especially in the larger arteries that they are remarkable,† both by their frequency, and by a sort of regularity or symmetry, and by the resemblance they then present with the regular state of certain animals.

§ 425. Besides the accidental vessels already indicated [371,] when a principal artery is interrupted in its continuity, there are established also other passages for the circulation. These new passages are commonly formed out of the ancient small vessels, but greatly enlarged, which were previously white, by their extreme thinness, become red, or which, being red and capillary, become more voluminous; but which, before this circumstance, formed, by their anastomoses, collateral passages [350]. In certain cases circulation is re-established through passages entirely of a new formation. This fact, the existence of which was suspected by J. Hunter, by Maunoir and even by Jones, although he controverted Maunoir's opinion, has been put beyond question by the experiments of Dr. Parry.‡ If the carotid artery of a sheep be tied, or a part be removed, an artery which furnishes no branches in the whole extent of the neck, we find some time after, the circulation re-established in the very place where the artery has been obliterated or cut off, by several branches nearly parallel, occupying the interval which exists between the divided extremities of the artery.

§ 426. The general inflammation of the arteries is of a rare occurrence; their local inflammation is, on the contrary, often met with. Simple redness, however, is not sufficient to characterize it; there is, moreover, some thickening or softening in

* *Deutschus archiv. fur die physiologie.*

† Fr. Tiedemann, *Tabulæ arteriarum corp. humani.* Calsruhæ, 1822.

‡ *Loc. cit.*

the parietes, and internally a plastic exudation, sometimes pus, and at others more or less extensive ulcerations.

§ 427. The wounds* of the arteries present anatomical considerations of great importance. The puncture of an artery gives rise to a feeble hemorrhage if the vessel be surrounded by cellular tissue; but it is greater if it be deprived of its sheath. The hemorrhage is arrested by the coagulation of the blood, which is afterwards gradually absorbed; there is, during a short time, a small enlargement opposite the puncture; afterwards so very perfect a cicatrix is formed, that it is impossible to perceive it. A small incision, lengthwise with the vessel, opens a little, and gives rise to a hemorrhage greater than that produced by the puncture. The cure is sometimes effectuated afterwards, and in the same manner. A transverse incision produces, by the considerable separation of its edges, a more or less serious hemorrhage, according to the extent of the laceration of its cellular sheath. The hemorrhage is the more serious, the more the incision involves, more than one half of the circumference of the vessel, a case in which, if left to itself, it continues or is renewed after being stopped, until death takes place. In the cases in which the lesion reaches only a small part of the circumference, if the sheath exists, after having bled more or less, the blood infiltrates and coagulates in it, and sometimes a cicatrix is formed, which, in man, is much less solid than the original parietes of the artery, and which becomes commonly the seat or the cause of a consecutive aneurism. When, on the contrary, the transversal division is much greater than one half of the circumference, the retraction, as well as the diminution of its size, which result from it, is such, that if the sheath still exists, the blood infiltrates, stops, and coagulates in it, and the cure may also take place. But in order that this may occur, the complete division of the artery is accomplished, and then this case belongs to the following.

§ 428. Whenever an artery of a mean caliber is cut across,

* J. F. D. Jones, *on the process employed by nature in suppressing hemorrhage, &c.* Lond. 1810.—Béclard, *loc. cit.*

either on a surface, the result of an amputation, or in the continuation of the soft parts, the blood issues in a full stream and by a constant jet, alternately rising and lowering until the circulation is greatly enfeebled; then the bleeding diminishes and stops, either to recommence one or more times when the weakness has ceased, and to continue even to death, or ceases altogether. In this latter case, very rare in the human species, the artery being retracted in its sheath and in the surrounding cellular tissue, the blood infiltrates and coagulates around the end of the vessel; it coagulates also in the end itself to a greater or smaller distance, always determined, however, by the situation of the nearest branch, through which the circulation still continues to take place. The extremity of the artery is then obstructed and plugged, nearly in the same manner as is the mouth of a bottle by the cork, and by the wax with which it is covered. The artery being no longer influenced by the alternate distention it previously experienced, gradually shrinks; its divided extremity undergoes traumatic inflammation, and becomes the seat of a plastic exudation; the blood, cogulated internally and externally, is gradually absorbed, the artery cotinues to contract, it is converted into a mere cord, and commonly disappears, or is changed into cellular tissue as far as the neighbourhood of the nearest branch, which continues to carry on the circulation.

§ 429. When an artery is distended lengthwise, it greatly elongates at first by sliding in its sheath, favoured by the cellular tissue which surround it; after yielding a great deal without breaking, it begins to tear internally. The external membrane is the last part torn, after being elongated and thinned nearly in the manner of a tube of glass melted and drawn over a lamp. After being torn, the extremities of the artery retreat less than they have yielded, and the blood jets out, at first, as in the preceding case; but ordinarily, it soon stops, never to reappear. This quick and entire cessation of the hemorrhage, which almost always occurs in similar cases, has been ascribed to the retraction of the artery and to other imaginary causes. I am convinced, by many experiments performed on animals, and by many observations made on man,

that we ought to attribute this remarkable phenomenon, to the more or less multiplied internal ruptures that the artery experiences before its total division at any one point. The phenomena which follow are the same as after the transversal section. (428.)

§ 430. A ligature applied to an artery, either when entire, or when it is cut as at the surface of an amputated limb, sufficiently tight to arrest the circulation in the vessel, cuts the inner and middle membrane, and, if the artery is healthy, without, divides the outer one. If the ligature is permitted to remain, the blood stopped in the vessel coagulates in its cavity as far as to the nearest branch. The division experienced by the inner membranes, the pressure exercised on the external ones and the presence of the ligature, induce an effusion of organizable matter, which produces at first the agglutination of all the injured parts; the part embraced within the ligature is at first softened, is afterwards divided by the effect of inflammation, and the ligature comes off. The changes which follow in the vessel are the same as after the transverse section. (428.)

§ 431. In the three kinds of wounds of which we have just treated, (428, 430.) the ulterior phenomena are different, according as they are made on an amputated surface or in the continuity of the parts. In an amputated surface, the principal artery is not only obliterated, but also its branches terminating at the surface, so that the trunk itself is more or less narrowed. In the other case, on the contrary, the branches which arise from the artery on which a ligature has been applied, divided or torn, not only continue to carry on the circulation, but dilate in order to supply the principal trunk; they thus keep up, even to the point where they arise, the fluidity of the blood, its motion, and its influence on the vessel. It is to this difference that must be ascribed the frequency of the primitive reunion of divided arteries on an amputated surface, and the comparative few cases of this happy result, when the division of the artery happens in the soft parts.

§ 432. We sometimes find a cartilaginous production or transformation, with thickening of the parietes of the arteries, commonly in a somewhat confined extent. Atheromatous,

steatomatous productions, &c. are, like the preceding, only the beginning of the calcarious ossification of which the arteries are so often the seat. This ossification is of two kinds, accidental and senile. The first has its seat between the inner and middle membranes, and is preceded by one of the above mentioned alterations. The second, on the contrary, has its seat in the middle membrane, and consists in a transformation of its fibrous rings into osseous ones, more or less extensive. The different parts of the arterial system are not every way equally predisposed to it. The aortic system is oftener affected by it than the pulmonary. The internal projections of the arteries, and the valves of their trunks, are frequently the seat of this affection; the aorta and its principal branches are often in the same case; oftener in the arteries of the inferior members than in those of the superior extremities; pretty often in those of the muscles, heart, brain and spleen; but rarely in those of the stomach and liver. Finally, Harvey, Riolan, and Loder, have observed the whole arterial system ossified. The ossification of the arteries most generally occurs in old age; accidental ossification, however, is also sometimes observed in young subjects, and in early infancy. This affection of the arteries is not so frequent in woman as in man. It is much more common in cold than in warm climates.

The effect of arterial ossification, and especially of that which is accidental, is to produce the wearing of the membranes between which it is placed. The ossification of the arteries has been ascribed to a great many causes. The accidental one is a true production or deposition; that which is senile seems to be the last conditions of the successive changes that the middle membrane experiences during life, but in the first period of which is soft and red.

§ 433. Excrescences of a fleshy consistence are sometimes found attached to the internal surface of arteries, and especially to the semi-lunar valves which are at their entrance.

§ 434. The dilatation of the arteries is a very common affection; it may consist: 1st, in a simple loss of elasticity without any apparent alteration of the parietes; 2d, in an alteration of the dilated parietes.

Simple dilatation is especially met with in the large trunks; it affects equally the whole circumference, and the tumour resulting from it has an ovoid form. It has often been observed in the aorta, particularly at its curvature, and sometimes in the pulmonary artery.

The dilatation, with an alteration of the parietes, affects the aorta and the different parts of the aortic system even to the ramifications. The arteries of the superior members are more seldom affected than those of the inferior. The alteration and dilatation which results from it, are most commonly lateral. This is the affection that authors have described, since Fernel, under the name of true aneurism. The altered parietes are rather thickened than thinned in it. The blood contained in these two kinds of dilatations is fluid.

§ 435. Aneurism is caused by the injury or rupture, in a word, by the solution of continuity of the arterial parietes, commonly preceded by the dilatation of these parietes, and always preceded by their alteration. It consists in a cavity formed by the outer membrane, dilated and strengthened on all sides by the cellular tissue and by the other surrounding parts; lined internally by a thin and in some places polished membrane, resembling very much the inner membrane of arteries. This cavity communicates with that of the vessel, through a passage sometimes regular, at others irregular, made in the inner and middle membranes; it is filled with coagulated blood, and with layers of fibrine more or less firm, differently altered, and perhaps mixed with organizable matter produced by the parietes of the cavity. The blood, in its circulatory course, penetrates continually into the accidental cavity.

Sometimes aneurisms enlarge indefinitely, and cause death by the compression they produce on the neighbouring organs and by the disturbance of their functions. At others it is ruptured either externally or internally, and causes death by hemorrhage or by effusion. At other times it inflames, suppurates and opens like a large abscess, and then sometimes hemorrhage occurs, or, on the contrary, the artery being obliterated by inflammation, a radical cure may follow. Some-

times inflammation terminates in the gangrene of the tumour, and either of the effects here above mentioned may be the result of the separation of the eschar. Finally, at other times, the circulation imperceptibly diminishes in the artery affected with aneurism, and becomes at the same time more and more active in the collateral passages or vessels, from which finally result the obliteration of the affected artery as far as the neighbouring branches of the tumour, and the gradual absorption of the latter.

§ 436. Arteries, inflamed or affected with an accidental production in their parietes, or without any apparent cause, instead of dilating and tearing, are sometimes narrowed, and even are obliterated spontaneously. Thus the aorta has been observed narrowed and even altogether obliterated; the total obliteration of the right pulmonary artery has also been remarked. I have seen once that of the carotid artery, several times the narrowing of the caliber of the brachial trunk, and often the narrowing and obliteration of the crural trunk and of its branches. This is the ordinary cause of senile gangrene of the toes, feet and legs; this change occurring in a part and at a time in which the arterial branches, they themselves being affected with hardening, are no longer susceptible of rapid growth, necessary to the re-establishment of the collateral circulation.

SECTION III.

OF THE VEINS.

§ 437. The veins* are the vessels which bring back to the heart the blood from every part of the body.

§ 438. We have already seen that the ancients have at first made no distinction between the veins and arteries. Galen,

* *Diatribe anatomico-physiologica de structurâ atque vitâ venarum*, Autore H. Marx, in 8vo. Carlsruhæ, 1819.

who distinguished them very well, placed the origin of the former in the liver. The difference and connexion between the arteries and veins have been perfectly established by the discovery of the circulation of the blood; since that time, the study of the venous system has been somewhat neglected.*

§ 439. The veins, like all the vascular system, have an arborescent disposition; but considered with respect to the direction of the course of the blood, they rather resemble the roots of a tree, than its branches. Thus their origin takes place by radicles, which correspond to the ramuscules of the arteries; their termination by trunks which open into the heart, like the origin of the arteries; their course presents reunions and successive divisions, like that of the arteries. If examined then, by following the course of the blood, they present a contrary disposition to that of the arteries; and if considered in the same direction as the arteries, we should follow a course opposite to that of the blood.

§ 440. The venous system, like the arterial, is double; the one general, returns the blood of the body to the anterior or right auricle; the other brings back the blood from the lungs to the other auricle of the heart. There is moreover a particular and complicated venous system in the abdomen: this is the vena porta, the disposition of which must be the object of a separate investigation.

§ 441. This particular venous system constitutes of itself a whole vascular system, that is to say, a tree having a trunk, roots and branches, placed between the last ramuscules of the gastric, intestinal and splenic arteries, which are continuous with its roots, and the first radicles of the sub-hepatic veins, which are the continuation of its branches. This vascular system, if we take into consideration its disposition, which is ramified in opposite directions, resembles the veins in its intestinal half, and the arteries in its hepatic half; under another relation, it is indifferent to both, being intermediate, for it is at the point where it is the continuation of the arteries, that it has the venous disposition and *vice versa*. This vascular

* Since our author wrote this passage, M. Breschet is publishing a most splendid work on the venous system; which see. TRANS.

system is comprehended in the general venous system, especially on account of the nature of the blood it contains.

§ 442. In the vertebrated oviparous animals another venous system, analogous to the intestino-hepatic vessels, is found. This particular system* is formed by the union of the veins of the middle region of the body only, or of this region and of the tail, which veins terminate in the kidneys in the same manner as the arteries, sending sometimes a branch to the vena porta, that is to say, to the liver. I have sometimes observed, in the dog, the vena porta to have one or two renal terminations.

§ 443. The number of veins is in general greater than that of the arteries. There are two venæ cavæ, and one cardiac vein to correspond with the single trunk of the aorta. There are, in the same manner, four pulmonary veins to correspond with the single pulmonary artery and its two branches. But each of these venous divisions corresponds with a branch of a corresponding artery. In almost the whole extent of the body, there are many more subcutaneous veins than arteries, and in deep seated parts, there are almost every where two venæ committes for a single artery. In the stomach, the spleen, the kidneys, the testicles, the ovaries, and some other parts, the number of veins is equal to that of the arteries. In some parts, the number of veins is even less than that of the arteries, as for instance, in the umbilical cord, in the penis, in the clitoris, in the gall-bladder, surrenal capsules, &c. But this is compensated by the difference of capacity. The size of the veins generally, is in fact more considerable than that of corresponding arteries.

The sum of the veins, or their total capacity, is then greater than that of the arteries. Many calculations have been made respecting it; but we can only say with Haller, that the veins are at the least double of the arteries in capacity. But, independently of individual, accidental, or temporary differences, and those which depend upon the kind of death, it continually

* Lud. Jacobson, *de systemate venoso peculiari in permultis animalibus observato.* Hafniæ, 1821.

varies with age. This difference, moreover, is not the same in all parts of the body. In the pulmonary system it does not exist, for the veins are there apparently equal in capacity to the arteries. This is also the case with the renal vessels. In the testicles, on the contrary, the veins are greatly superior to the arteries.

§ 444. The situation of the veins is generally the same as that of the arteries, these two kinds of vessels accompanying each other in their course, and uniting at their termination. Almost every where, a trunk, a branch, or a twig of an artery, is accompanied by one or two veins. There are, however, exceptions: thus, in the cranium, the spine, the eye and liver, the arteries and veins affect different situations and dispositions; the vena azygos, the trunk of the intercostal veins in the space between the pericardium and liver, is not accompanied by an artery, and this is also the case with the subcutaneous veins.

§ 445. The veins commence by capillary or microscopic radicles, forming a continuation of the ramuscules of the arteries. These radicles are colourless or red, according as their diameter admits a single series of globules, or several at once. In some places, as in the intestine, the lungs, &c., the successive reunion of the radicles of the veins corresponding with, and entirely similar to the divisions of the arterial ramuscules. In other places the disposition is different. Without speaking of the erectile or cavernous tissue, in which the swelling and communication of the veins are extreme, in many other parts they have different dispositions from those of the arteries: they form plexuses at the neck of the bladder, in the spine, and around the spermatic artery, wide canals in the spongy bones, and under the skin, they form, by their numerous communications, a great vascular net-work with angular, and most ordinarily meshes.

They are not so regularly cylindrical as the arteries, and so far from following a regular order of increase in the volume of the trunks and of decrease in their total capacity, very large branches are sometimes seen connected with a trunk of no great size, which depends especially on the softness of the

parietes and the great number of anastomoses. The communication of the veins present all the varieties already indicated [356,] and moreover, the union of the very large trunks, as that of the venæ cavæ by the vena azygos; the union of superficial and deep seated veins, as that of the cranial and spinal veins with the epicranial, temporal, cervical, &c., that of the internal and external jugular veins, and that of deep seated veins, with the subcutaneous veins of the limbs.

Generally, the veins have a less flexuous, straighter, and therefore, shorter course than the arteries.

The variations of the veins have been a little exaggerated, and those of the arteries have been somewhat concealed. The large venous trunks especially are less variable than they have been announced; but the branches and twigs are very much so.

§ 446. The interior of the veins present a great number of valves* or folds of the inner membrane, which constitute a great difference between them and the arteries. The valves are very well seen by examining under water a vein split open lengthwise.

Each valve consists in a fold of the inner membrane. This fold has a convex edge, adhering to the parietes of the vein on the side towards its radicles, and a concave and free margin, turned towards the heart. These two edges are somewhat thicker than the rest of the fold; one of the surfaces is turned towards the cavity of the vessel, and corresponds to the circulating blood, the other corresponds to the parietes of the vein, somewhat dilated at this point. When the valve shuts, the surface, which corresponds to the radicles, becomes convex, the other becomes concave, and the vein slightly enlarges; the valves are so much the more broad as the vein is the more voluminous, and so much the more elongated as it is smaller. It is to this difference especially that the varieties of form described by Perrault and several others is to be referred.

* H. Fabricio, *de venarum ostiolis, in op. omn.*—J. G. Schmiedt and Meibomius, *de valvulis seu membranulis vasorum earumque struct. et usu.* Helmst. 1682.—Perrault *Essais de physique*, tom. iii.

Besides the inner membrane, there exists also in the substance of the valves, dense cellular tissue, and sometimes distinct fibres; sometimes they are areolar and perforated like lace. In the veins or sinuses of the dura mater, there occur only some transverse fibres, which may be considered as rudimentary valves.

The valves are generally disposed in pairs placed alternatively, according to two opposite diameters of the vein.

They are three, and three in the great veins, as in the crural and iliac; they are seldom observed quadruple, and very seldom or never quintuple. In twigs, with a diameter of half a line and less, they are single.

There are by no means valves at all the places where a twig unites to a branch, or where a branch opens into a trunk; nor are they everywhere at the same distance; they are nowhere closer to each other than in the smallest veins. Valves are found in the veins of the extremities, more in the subcutaneous than in the deep seated ones, in those of the face, neck, tongue and tonsils, at the termination of the cardiac vein, in the tegumentary veins of the abdomen, in those of the testicles, penis and clitoris, in the internal and external iliac veins, sometimes in the renal veins, and rarely in the vena azygos.

There are none in the encephalic, spinal and diploic veins, in those of the lungs, in the vena porta, in the umbilical vein, in the venæ cavæ, if we except those at the entrance of the vena azygos, in the uterine veins, and in the median vein.

There are generally a great many valves in the superficial veins, fewer in the deep seated or intermuscular veins, and still fewer in the veins of the splanchnic cavities; they are numerous in the most depending parts, and therefore in the lower extremities, less so in the upper, and still less numerous in the head and neck.

The valves are applied against the parietes of the veins, when the course of the blood is free and easy, but when it meets with obstacles in its passage, the valves separate from the walls, close the vein, sustain the blood, and prevent its reflux towards the capillary vessels.

§ 447. The veins, like all the vessels, are surrounded by the cellular tissue of the parts in which they are situated, which forms a sheath, loose around the trunks, but more intimately united with the twigs. The sheath of the vena porta is remarkable in the liver, where it is known under the name of capsule of Glisson.

The outer membrane, properly so called, is thinner and less condensed than that of the arteries, to which it bears a great resemblance. The inner membrane is formed of fibres more extensible and softer than those of the arteries. These fibres appear nearly all longitudinal, when the membrane is examined and held between the eye and the light; some of the most internal fibres seem annular; but when we wish to separate the fibres of this membrane, the same difficulty is experienced in all directions. In the human species this membrane is much thicker in the system of the inferior vena cava than in the other; generally it is also thicker in the superficial than in the deep seated veins; thus the internal saphena vein has very thick parietes at the lower part of the leg. Near their entrance into the heart, the veins have distinct muscular fibres. The inner membrane, which is thin and transparent, differs from that of the arteries by its extensibility and its resistance to rupture, and by its filamentous texture, which becomes evident when it is distended and torn. The large veins of the cranium or sinuses, the veins of the bones and some others, are almost entirely constituted by the inner membrane, and are besides, as it were, scooped out in the substance of the dura mater, the bones, &c.

The parietes of the veins are provided with small blood vessels and nervous filaments, which may be followed for a certain extent.

§ 448. The parietes of the veins are whitish, semi-transparent, thinner than those of the arteries; generally their thickness augments absolutely from the roots towards the trunks, and diminishes, when compared with the diameter, by following the same course. Their density is of 115 or 110; the firmness of their walls is much less than that of the arteries, for this reason they collapse when empty, with the exception

of those of the uterus, the liver, &c. which are attached to the substance of the organs. They are less extensible in the longitudinal direction than the arteries, but much more so in the circular. Since Wintringham's experiments, it is generally admitted that the veins oppose a much greater force to the causes of rupture than the arteries; on the other hand, they not only yield much more to distention, but also tear across, much more frequently than the arteries, while, on the contrary, they have appeared to me to resist greater distention longitudinally. The parietes of the veins are very elastic, but less so than those of the arteries. Their irritability or vital contractility is, on the contrary, greater than that of the arteries, but less than that of the capillaries. It has been denied by several physiologists, but proved by many experiments. It is sufficient to have observed the effect of local cold on the subcutaneous veins, and to know that the portion of a vein between two ligatures, when punctured, empties itself entirely and rapidly in a living animal, while this does not occur after death, to admit the existence of irritability in the veins. Their sensibility is obscure or doubtful; Monro, in his lectures, affirmed that he had felt the puncture of a denuded vein. The force of formation of the veins is not less evident than that of the arteries.

§ 449. The function of the veins is to convey the blood from every part of the body to the heart. We have seen that each contraction of the ventricles determines an augmentation of the continuous movement of the blood in the arteries; this augmentation goes on diminishing in the same degree as the vessels become capillary. In these latter, as well as in the veins generally, the movement is uniform. The blood in the veins is animated by the movement imparted to it by the heart, the arteries, and by the capillary vessels. Do the veins exercise an additional action? This is not doubtful; let any one compress or tie the artery of a member in an animal, the flow of the blood in the veins will be slower; but will not be for this stopped; if a vein be tied, it will however empty itself above the ligature, it empties itself even between two ligatures. To the causes already mentioned, we must add the

alternate relaxation of the heart, which produces a kind of attraction; inspiration, which produces a still more powerful one, and the compression of the surrounding muscles. The valves, by dividing the column of the blood, render these diverse powers more efficacious. The form of the venous system is the cause that the movement of the blood, instead of gradually diminishing, as in the arteries, is, indeed, slower than these latter, the capacity of which is less than that of the veins, but however, go on accelerating as it approaches the heart. The venous circulation is much more dependent than the arterial on the effects of gravity and pressure.

§ 450. The course of the blood in the veins is continuous, and these vessels do not present any pulsations; in some places and under certain circumstances, however, they present something analogous to an arterial pulse, which for this reason is called venous pulse. In the neighbourhood of the heart, the venous trunks, which are deprived of valves, experience alternately, during the contraction of the auricles, a reflux of blood which makes them swell out, and during the relaxation of the auricles there occurs a rapid flux, which causes the veins to be depressed. In the ordinary and regular state of functions, this double movement is confined to the vicinity of the heart and is not sensible; but when the circulation is embarassed it extends into the abdomen, and becomes visible in the neck. It is the same with the influence of the motions of respiration: inspiration accelerates the entrance of the blood into the venæ cavæ and their auricle; active expiration, difficulty or suspension of respiration, and efforts, on the contrary, slacken or suspend it; in the ordinary state, these effects are little appreciable or extended; but they become very much so in the opposite cases. The efforts, in which the effects of active expiration are carried to the highest degree, determine, in a very sensible manner, the stasis of the venous blood in the head, the abdomen, and gradually even as far as the limbs; while it is to the contrary effects of inspiration on venous circulation, that we must ascribe death by the introduction of air into the heart. When, in fact, by an operation or accident, a large vein is opened at the base of the neck or in the subcla-

vian region, a deep inspiration sometimes draws air into it, which is sucked into the right cavity of the heart, and which, by stopping the circulation, produces sudden death.

§ 451. In youth the venous system is less extensive, in proportion to the arterial system, than in the adult age; its relative capacity continues to augment in old age. The parietes of the veins offer small observable changes; their senile ossification is extremely rare.

§ 452. The morbid alterations of the veins,* have been less studied than those of the arteries.

The inflammation of the veins or phlebites, is an affection to which Hunter has been one of the first to draw the attention of the profession. It ordinarily occupies a considerable extent of the veins, and generally extends towards the heart. It often gives rise to the formation of pus, and at other times to that of plastic matter in the cavity of the vein, around it, and even in its own thickness. It mostly depends on mechanical lesions.

§ 453. Wounds of the veins, considered under an anatomical point of view, present some analogy with those of the arteries; but, in whatever mode they are inflicted, they are much more easily followed by ulceration or extension and often suppurative inflammation than those of the arteries, and they unite with more difficulty. After puncture or incision, there remains between the edges a space filled by a new membrane; the ligature does not first determine the division of the inner membrane and quickly its adhesion, but this membrane is at first only plaited, and is divided but slowly in order to unite feebly.

§ 454. Accidental productions are more rare in the parietes of the veins than in those of the arteries. The cartilaginous, or an analogous thickening, occurs however sometimes in the parietes of the veins which are obliterated; Morgagni observed it once in the vena cava. Ossification is extremely rare in the veins. Dr. Baillie has seen it once to occur in the vena cava inferior near the iliacs, and Dr. Macartney once

* Hodgson, *op. cit.*—B. Travers, *Surgical Essays*, part first.

in the external vena saphena of a man who died with an ulcer on the leg. I have observed that the parietes of the veins are thicker on the side which touches an artery, than in the remainder of their circumference, and I have once seen in an old man a femoral vein ossified on the side next to the artery, which itself was ossified throughout its circumference and for some extent of its length.

Morbid productions are sometimes observed under the form of vegetation, at the internal surface of the veins, whether the affected vein be surrounded by similar productions, or not.

§ 455. The dilatation of the veins is very frequent, and is of various kinds; sometimes the whole venous system is affected by it; very often dilatation affects one or some veins only, which constitutes varix. Almost every part of the body may be the seat of it; however, the most depending parts are those most subject to it, as the inferior limbs, the genital organs and the anus; it is also the most superficial veins, as the subcutaneous, which are oftener affected. The augmentation of the volume is not only in the circular dimension, but varicose veins form a great many flexuosities which are ascribable to the increase of their length. Sometimes dilatations of very little extent, and confined to a part of the circumference of the vein are found, either alone, or together with more general dilatations. Varicose aneurism is another kind of dilatation depending on the accidental communication of an artery and a vein, and on the passage of the blood from the former into the latter. This affection is commonly accompanied with a remarkable thickening of the parietes of the elongated and dilated vein. Moreover a consecutive aneurism is sometimes formed between the two vessels: this case constitutes the varicose aneurism.

§ 456. Veins become sometimes narrow in consequence of the thickening of their parietes: they are sometimes closed by the effect of plastic inflammation; sometimes they are compressed by neighbouring tumours, or embraced within a ligature. In those cases, in which their cavity is obliterated, and in which circulation no longer occurs, the blood passes

through branches and anastomoses, and a collateral circulation is established.

The inferior vena cava has been found obliterated, either under, or even on a level with the subhepatic veins, and the blood passing through the vena azygos; one of the primitive iliac veins, one of the jugular veins, &c. have been several times found obliterated. Four times I have seen the trunk of the crural vein obliterated in the groin, and in every instance the circulation was easily carried on by collateral passages. Hunter once observed the superior vena cava and the left bracio-cephalic vein almost entirely destroyed by the pressure caused by an aneurism. I have seen a case, however, in which the superior vena cava and its branches were filled with plastic matter, and impermeable to blood, and in which death appeared to have been the result of this alteration. I have remarked several times, but not always, great serous infiltrations coinciding with the obliteration of the veins.

§ 457. Small, hard and round bodies are sometimes found in the veins, which on a superficial observation might be taken for accidental osseous productions. Some writers have even supposed that they were at first formed in the parietes of the veins, in the edge of their valves, or even on the exterior of these vessels; but this is not true. They are concretions, phlebolites, from the size of a grain of millet to that of a pea, of various consistence, formed of superincumbent layers, inclosed in the coagulated fibrinous blood, and often lodged in the lateral dilatations of the veins where the blood stagnates, or in the varicose veins, and always in the depending veins. The veins in which they are, in fact, most commonly met with, are those of the anus, the neck of the bladder, the uterus, the ovaries, the testicles, and sometimes even the subcutaneous veins of the leg.

The *hexathyridium* or *polystoma venarum* of which Treutler found two in the ruptured tibial vein of a man, who had been washing in a river, seems to be an aquatic worm, a *planaria*, which had found its way in it, and not an (*entozoaire*) entozoary.

SECTION IV.

OF THE LYMPHATIC SYSTEM.

§ 458. The lymphatic system comprehends, 1st: the vessels which convey the lymph and chyle into the veins, and 2d enlargements occurring in their course, and which are called conglobate glands, or lymphatic ganglia.

ARTICLE I.

OF THE LYMPHATIC VESSELS.

§ 459. The lymphatic vessels, called also absorbents, are so attenuated, thin and valvular, which renders their observation and injection very difficult, that the knowledge of their existence is rather of a recent date. The ancients, however, had a glimspe of them. Erasistratus and Erophilus had certainly perceived the chyliferous vessels. It is Eustachio who has discovered the thoracic canal in the horse. Aselli saw and called lacteal vessels, the chyliferous vessels of some animals. He points out very well their functions. Veslingius is the first who saw the chyliferous or lymphatic vessel of the mesentery and thoracic duct in man. We owe to O. Rudbeck the discovery of the vessels of this kind in the other parts of the body, although it has also been ascribed to Th. Bartholin and to Jolyf. The discoverer gave them the name of serous, aqueous, or lymphatic vessels. Bartholin conjectured that they were, like the veins, continuous with the capillary arteries, and destined to convey the watery part of the blood. Ruysch has very well described their valves. The knowledge of the lymphatic vessels has been very much increased by the labours of Meckel, Monro, by those of W. Hunter, and of three of his disciples, J. Hunter, W. Hewson,*

* *Descriptio systematis lymphatici, ex anglico versa, in op. omn.* Lugd. Bat. 1795.

and Cruikshank;* especially by those of the illustrious P. Mascagni,† and by some other writers,‡ all of whom have ascribed to them patulous orifices, and absorption to these orifices.

§ 460. These vessels are commonly distinguished into chyliferous and lymphatic vessels; but this distinction is entirely superfluous and without any utility, for their disposition, their texture and their functions are the same.

§ 461. The lymphatic vessels have an arborescent disposition, like other vessels. The humours which they contain, pass through them, like the veins, from the ramifications, or rather from the roots, towards the trunks. The aggregate of these vessels consists in a principal and an accessory trunk, in which numberless roots terminate.

§ 462. Lymphatic vessels are found in every part of the body, excepting the spinal marrow, the brain, the eye and the placenta.

Their situation is remarkable, that in the limbs and in the parietes of the trunk, they are, like the veins, distributed in two plans, the one superficial or subcutaneous, the other intermuscular or deep, which accompanies the blood-vessels and nerves; and that in the splanchnic cavities there occurs, also, a plane of lymphatic vessels, situated immediately under the serous membranes, and others more deeply seated.

§ 463. The number of lymphatic vessels is very considerable; as many as twenty are counted in the superficial plane of the inferior limbs accompanying the inner saphena vein alone, and a smaller, but still considerable number, accompanies the deep seated vessels. The superficial lymphatic vessels are

* *Anatomie des vaisseaux absorbans du corps humain*, traduite de l'anglais par Petit Radel. Paris, 1787.

† *Vasorum lymphaticorum corp. hum. historia et ichonographia.* Senis, 1787.

‡ Ludwig, *a German translation of Cruikshank and of Mascagni, with additions.* Lips. 1789.—Werner and Feller, *Vasorum lacteorum atque lymph. anat. physiol. descriptio.* Lips. 1784.—J. G. Haase, *de vasis cutis et intestin. absorbentibus, &c.* Lips. 1786.—Schreger, *Fragmenta ana. et physiol. fasc.* i. Lips. 1791.

less voluminous than the deeply seated ones. The size of these vessels is much less than that of the veins. Those of the inferior extremities are larger than those of the superior members, those of the head are very small. As to their aggregate capacity, it has not been accurately determined; it appears generally to be nearly double that of the arteries, and to equal that of the veins in the superficial plane at least.

§464. The origin of the lymphatic vessels is invisible and unknown. Physiological considerations and anatomical experiments have caused authors first to admit and then to reject their direct and immediate continuation with the arteries. We have also seen that the origin admitted to take place by open orifices at the surface of the two tegumentary and serous membranes, in the areolæ of the cellular tissue, and in the substance of the organs, which has been deduced from considerations and experiments of the same kind, is not better founded. It is well to know how to doubt.

§465. As soon as they can be perceived, the radicles of the lymphatic vessels are seen to unite together, to separate, and unite anew, so as to form net-works which constitute in a great measure the serous, tegumentary and other membranes.

These vessels become generally larger and more numerous as they are farther removed from their origin. In their course they continue to divide into branches, which reunite with other neighbouring branches, or even with each other, so as to form parts entirely surrounded by liquid. These divisions and these numerous anastomoses form plexuses in many places.

When they are full and a little distended they appear rather moniliform than cylindrical. This appearance of a rosary is owing to the great number of valves with which they are provided, and to the dilatation which they present above them. They also frequently present ovoid dilatations. We observe in them many variations in their course: those of one side always differ more or less from those of the other.

All the lymphatic vessels, after a longer or shorter course, ramify in the same manner as the arteries, and seem to terminate in lymphatic glands, beyond which they reappear again

formed of roots, which collect themselves in the manner of veins. In those of the members, for the distance of several feet, there are no interruptions of this kind; in those of the mesentery, every few lines there are glands. Some pass along side of a gland without entering it. It would even appear, according to Cruikshank, that the lymphatic vessels of the back arrive at the trunk without meeting any glands; but Mascagni, whose authority in these matters is so great, assures us that no lymphatic vessel reaches the trunk, unless it has passed at least through one gland.

§ 466. After a course more or less long, more or less interrupted by ganglions, the lymphatic vessels of the inferior half and of the superior and left quarter of the body, terminate by a very elongated trunk, the thoracic duct, into the left subclavian vein; the others terminate by a very short trunk in the other subclavian vein. These modes of terminations are themselves subject to different variations. Does there exist other terminations of the lymphatic vessels in the veins? A part of this query must be examined here, and the other when we shall speak of the lymphatic ganglia.

Several anatomists and physiologists have admitted this opinion,* which may be founded on the circumstances that every where, and especially in the mesentery, the known radicles of the lymphatic vessels have a capacity much greater than that of the vessels which form their continuation; on the circumstance that in this part of the body, also, there is often found in the veins, as in the lymphatic vessels, substances introduced by absorption, and even those which have been directly injected into these latter vessels; and finally, on the circumstance that the mere tying of the thoracic duct, causes death only after ten or fifteen days, and that the substances introduced into the intestines, and absorbed by its internal membrane, are then found in the blood. But this communication has never been seen, nor is it generally admitted. It would appear to be especially in the lymphatic glands that it occurs; but we shall revert to this subject hereafter, (*art.* ii.)

* *See* Ludwig, *loc. cit.*

§ 467. The surfaces of the lymphatic vessels, like those of all the vessels, are the one cellular and adherent, the other smooth and free: the latter presents a multitude of valves.

These valves, which are of a semilunar or parabolic form, are mostly arranged in pairs, and are large enough to close the vessel completely. They are generally placed at unequal intervals, excepting in the vessels of the testicles, where they occur nearly every line, which gives them more than any other the appearance of a chaplet. They are more or less close, according to the parts, without their being more particularly so in the branches than in the twigs; in certain vessels there occurs spaces of several inches without valves: the thoracic duct is especially remarkable in this respect. In some points the insertion of a small vessel in a larger one is only furnished with a single valve. In some places of the trunks annular valves, that do not entirely close the canal, are found. The insertion of the trunks into the subclavian veins is furnished with a double valve, which effectually prevents the reflux of the blood from entering into their cavity. All these valves, like those of the veins and arteries, are formed of a duplicature of the inner membrane.

§ 468. Lymphatic vessels are formed of two membranes, very distinct in their principal trunks.

The external, cellular and unequal or exterior is united to the surrounding cellular tissue, which invests it with a sheath; more deeply, it is distinctly fibrous or filamentous: it is even supposed that muscular fibres have been observed in it. The inner membrane is very thin.

Small sanguineous vessels, arteries and veins, have been followed up into the thickness of the outer membrane; some say that they have also seen in it lymphatic vessels. No one has ever been able to perceives nerves in them.

§ 469. The parietes of the lymphatic vessels, although very thin and transparent, are dense and very resistant, much more so than those of the veins, taking into consideration the difference of their thickness. Nevertheless, these vessels are extensible, and also very retractile. Elasticity is manifest in them:

if they are filled and distended in the subject, the matter which is introduced into them, is rejected.

Vital irritability or contractility* is no less evident in them: although Mascagni and several others have denied it. If they be exposed to the air in a living subject, they manifestly contract; if the thoracic duct or any other lymphatic vessel be punctured after being tied, the liquid issues by jets, like the blood which comes from a vein, while after death, it only escapes in a sheet over the lips of the wound. It is true that mechanical or chemical irritations do not produce movements similar to those of the muscles, but we must observe that irritability varies according to the organs.

We know nothing concerning their sensibility, and little about their force of formation.

§ 470. The lymphatic vessels contain the chyle and lymph [79]; they convey these humours from their radicles to their trunk, which is very well proved by the arrangement of their valves, which permits the fluid to flow in that direction, but prevents it in an opposite one; by the effects of the ligature, below which they swell while they empty themselves above; and by the valves which are placed at their insertion in the veins. The passage of the liquids through them is slow and uniform, that is to say, they do not present any pulsation.

Darwin, Thilow and others, in order to explain the rapidity of certain secretions, have admitted a retrograde movement of the humours in the lymphatic vessels: in such a manner, for instance, that the liquid absorbed by the parietes of the stomach should be directly conveyed by the lymphatic vessels, and by means of their communications to the kidneys, and hence to the bladder. This would be to admit that the valves do not present a very great obstacle to the retrograde motion of the liquids. But it is certain, on the contrary, that the valves oppose an insurmountable obstacle to the return of the liquids; and moreover, observations and direct experiments cause us to discover in the urinary passages substances intro-

* Schreger, *de Irritabilitate vasorum lymphaticorum*. Lips. 1789.

duced into the stomach, without the intermediate lymphatic vessels presenting the smallest evidence of their passage.

ARTICLE II.

OF THE LYMPHATIC GANGLIA.

§ 471. The conglobate or ovoid glands, which interrupt the continuity of the lymphatic vessels, stand in the same relation with respect to these vessels, as the nervous ganglia to the nerves.

The ganglia were very anciently known. It is partly of them that Hippocrates speaks under the name of glands. Fr. Sylvius has given to them the epithet of *conglobate*, and Lossius that of *lymphatic* glands. According to the comparison above mentioned and made by Sœmmering, and to avoid confusion, M. Chaussier has designated them under the name of lymphatic ganglions.

§ 472. They are situated in the course of all the lymphatic vessels, beginning at the instep and at the fold of the arm, at the elbow for the members, at the carotid canal and at the exterior base of the cranium for the head. Many of them exist in the neck, in the arm-pit, in the groin, several in the anterior parietes of the thorax and abdomen, and a very great number in these cavities. They exist especially very abundantly about the roots of the lungs and in the mesentery, near parts, consequently, which admit much extraneous matter. None are known to exist in the cranium or in the spine.

Their size varies, in the healthy state, from that of a lentil to that of an almond. Generally, the smallest are situated towards the origin of the vessels, and the largest towards their trunks. The most voluminous and closest to each other are formed towards the root of the mesentery, the smallest in the epiploon; those of the head and arms are small.

Their figure is rounded, oblong and a little flattened; they are more or less unequal at the surface; they generally have the form of an almond.

The lymphatic ganglia are generally of a reddish white, similar to flesh, but their colour varies according to the regions they occupy; thus those which are subcutaneous have a deeper colour; those in the environs of the liver are yellowish, those of the spleen brown, those of the lungs blackish, those of the mesentery very white, &c.

Their consistence is greater than that of any soft part.

§ 473. The lymphatic ganglions are enveloped in a thin fibrous, very vascular, membrane, united to the surrounding cellular tissue, and which sends fine and soft prolongations into the interior.

The lymphatics, whose course is interrupted by glands, are distinguished into those which come to these glands, *vasa inferentia*, and in those that issue from them, *vasa efferentia*: they are distinguished from each other by the direction of their valves. The number of *vasa inferentia* is very variable, they may be from one to twenty or thirty; that of the *vasa efferentia* is also variable, seldom correspondent, and ordinarily fewer. The first mentioned enter the gland on the side nearest to the origin of the system, the others issue from the opposite extremity, which corresponds to the trunks. The vasa inferentia, in approaching the gland, divide themselves into twigs, which go off radiating around it, divide and subdivide themselves at its surface, so as to surround it with a net-work. The vasa efferentia produce nearly the same effect at the other extremity of the gland, by the successive reunion of their radicles and of their roots in trunks more or less numerous and voluminous. The total capacity of the vasa efferentia seems generally smaller than that of the vasa inferentia; this is particularly obvious in the mesentery.

The lymphatic glands have also remarkable sanguineous vessels. The arteries are sufficiently numerous and voluminous, so that when injected, the glands are entirely coloured by it. The veins, still more voluminous than the arteries, are deprived of valves. Nervous filaments may be seen reaching these organs and transverse them; but it is very difficult to ascertain whether some filaments terminate in them, or whether they are merely crossed by them all. Two great anato-

mists entertain opposite opinions on this subject: Wrisberg admits them, and Walter rejects them.

§ 474. Anatomists do not agree any better with reference to the internal conformation and the texture of the lymphatic glands. Albinus, Ludwig, Hewson, Wrisberg, Monro, and Meckel, consider their tissue as entirely vascular; Malpighi, Nuck, Mylius, Hunter and Cruikshank, admit of cells in them; Sœmmering admits these two kinds of texture, and a third resulting from their combination. The examination I have made myself of this tissue in man, in several animals, and especially in the inguinal glands of cows which died during lactation, has shown me that it results entirely from vessels, but which present an erectile disposition more or less obvious. In fact, among the vasa inferentia which penetrate into the thickness of the gland, some acquire and preserve a great tenuity, others dilate in cells like the veins of the penis, both having numerous anastomosing communications. The roots of the vasa efferentia present, on the other hand, the same disposition, that is to say, that some are fine radicles, and the other roots swelled or dilated in cells. The greater number of the lymphatic glands present in their interior this mixture of minute ramifications and enlarged parts. Some only present twigs dilated in cells; some others, seem to consist only in a net-work of fine ramifications. It is by these varieties that we may explain the diversity of opinions which has existed on this point of anatomy.

The lymphatic glands contain in their interior a cream-like substance, which appears to be contained in the fine or large vessels which compose them, and not in the cellular tissue.

§ 475. These ganglia are more voluminous, softer, more reddish, and contain more liquid in children and young subjects than in adults; they greatly diminish, but do not disappear in old age. There is no well marked difference in this respect between the two sexes. Hewson says that they are larger in man; Bichat says, however, exactly the reverse. Under the skin of negroes they are found black.

§ 476. The function ascribed to the lymphatic glands is, that they serve to mix the liquids arriving by the different

vasa inferentia, and to the elaboration of the lymph and chyle. The liquids are afterwards conveyed away by the vasa efferentia, and perhaps in part also by the veins. This point has been denied by many celebrated anatomists and physiologists, such as Haller, Cruikshank, Hewson, Mascagni, Sœmmering, &c.; but it is to be feared that the authority of these great men, may have caused a truth to be rejected, without previous examination.

Besides the facts already related favouring the opinion in question, we may remark that many observers have perceived striæ of chyle in the vena porta; we may add that a great many anatomists have seen and I have often seen, the mercury introduced into the lymphatic vessels of the mesentery, pass beyond a gland, both in the vasa efferentia and in the veins of the gland; now this passage is too easy and too constant to depend on a double rupture, and not to a natural communication of the *lymphatic* vessels and *veins.*

§ 477. Besides the lesions of the glands and lymphatic vessels,* such as the inflammation of both, the wounds and ruptures of the vessels, their varicose dilatation, their narrowing and obliteration, tubercles and other morbid productions in the glands, &c. authors have caused the lymphatic system to play a very great and indeed exaggerated part in most diseases, by considering it as an apparatus of absorption.

* S. Th. Sœmmering, *de morbis vasorum absorbentium corp. hum.* in 8vo. Traj. ad Mœn. 1795.

CHAPTER V.

OF THE GLANDS.

§ 478. The name of gland,* *glandula*, αδην, is derived, according to Nuck, from the similitude the ancients thought to perceive between the lymphatic ganglions or glands, and the fruit of the oak.

Objects so different have been comprised under the name of gland, that much difficulty is experienced in defining it.

Hippocrates had announced that the glands were formed of a peculiar granular and spongy flesh, not dense, having the colour of fat, the consistence of wool, easily mashed between the fingers, provided with numerous *veins*, and when cut emitting whitish and serous blood. He comprehended many parts under this name, and especially the brain.

Anatomists for a long time also had a vague idea of the glands, they have ascribed to them a rounded form; they then have comprehended with the glands and the vascular ganglions, the pineal gland, and hypophysis of the brain, the synovial adipose bodies, and even the tongue.

Another definition, founded on the texture, and in which there entered the idea of a mass of follicles or an aggregate of

* Warton, *adenographia*. Lond. 1656.—M. Malpighi, *de viscerum structurâ, in op. omn. et de struct. glandul. conglob. &c. in op. posth.*—Lossius and Pielow, *Disq. de glandulis in Genere*. Viteb. 1683.—A. Nuck, *Adenographia curiosa*. L. B. 1691.—G. Mylius, *de glandulis*. L. B. 1698—L. Terraneus, *de Glandu. universim, &c.* L. B. 1729.—Boerhaave and Ruysch, *de Fabrica glandular, &c. in Ruyschii op. omn.*—A. L. de Hugo, *comment. de glandulis in genere, &c.* Gotting. 1746.—Th. de Bordeu, *Recherches anatom. sur les glandes, &c.* Paris, 1751.—G. A. Haase, *de glandularum definitione*. Lips. 1804.—Leonhardi, *op. cit.*

vessels with a peculiar membranous envelope, still comprehended many different parts, and supposed an exact knowledge of the intimate texture.

It has also been attempted to define the glands by their function, by saying that they are secreting organs; but by afterwards confounding nutrition and secretion, the greater number of the organs were included in this definition; or by distinguishing these functions from each other, but not separating intrinsic from excretory secretions, the serous and synovial membranes were confounded with the glands.

In order to distinguish the glands from all other parts analogous to them in form, in apparent texture, and even to a certain extent in functions, we must take particular notice of their connexions; Bichat and Chaussier have taken this consideration for the basis of a definition of the glands: Haase has likewise adopted it; but he has supposed excretory ducts to the vascular ganglions. The glands are organs of an obround lobular form, surrounded with membranes, having many vessels and nerves, and provided with ramified excretory canals which terminate at the surface of the tegumentary membranes and pour out a secreted liquid. Finally, these are the organs of extrinsic secretions furnished with excretory ducts.

§ 479. The glands, when thus considered, are mere appendages or prolongations of the tegumentary membranes. In animals provided with vessels and a heart, the only ones which have massive glands, they result from the intimate reunion of these two kinds of organs: this is the reason why their description is placed here. They belong, however, more to the tegumentary than to the vascular system, for in animals deprived of vessels, glands exist, but in a rudimentary state; the liver, the most constant of all the glands, the kidneys excepted, exists, in fact, in insects under the form of a ramified excretory canal, terminating in the intestinal tube, but floating and free in the abdomen.

§ 480. It is also pretty difficult, and perhaps impossible, to establish a well marked line of distinction between the follicles or cryptæ and the glands.

We have already stated, that among the follicles some were simple and solitary, others are grouped, collected or aggregated, others again are composed either by their reunion in a common orifice or lacuna, or at the same time by the agglomeration of several follicles, or finally by a common and ramified excretory canal. Here a difficulty presents itself, for there is no good reason why the amygdales which have compound lacunæ, the molar glands, the prostate and Cowper's glands, which have ramified ducts, should not be classed among the glands, as well as the sublingual, the lachrymal glands, &c.

The most perfect and least equivocal glands are: the lachrymal, the salivary, three in number on each side, viz. the parotid, the maxillary and sublingual; the pancreas, the liver, the kidneys, the testicles and mammæ. The ovaries like the testicles must be classed with this kind of organs.

§ 481. The form of the glands is irregularly round, and present a great variety. Some are single, like the liver and pancreas, not symmetrical; others are double and very nearly alike on both sides.

§ 482. They are all situated at the trunk, and all, whatever may be the apparent diversity of their situation, terminate by their ducts in the mucous membrane or in the skin.

§ 483. Their size differs greatly: the liver is one of the most voluminous organs of the body, and on the other hand, the lachrymal and sublingual glands, and the ovaries are scarcely half the size of the thumb.

§ 484. In their interior, some are lobed and lobulated like the lachrymal and salivary glands and the pancreas; the mammæ are less distinctly so; the testicles are so in another manner; the kidneys are only so in the fœtus; the liver is only lobed externally.

In the former, the lobules seem to be formed of very small particles, but similar and whitish; in the liver and kidneys, we find two substances of different colour, arranged in layers in the kidneys, and mixed in the manner of fine granite in the liver.

§ 485. The greater number of glands are enveloped with a

cellular membrane, and some with a fibrous one, some of which are surrounded by a serous membrane, and others by a great deal of cellular and adipose tissues. The internal face of this membrane is continuous with the cellular tissue, more or less loose, which exists abundantly in the glands.

These organs have many sanguineous and lymphatic vessels, and few nerves; more, however, than the mucous membrane generally, but less than the skin. The greater number receive only arterial blood; the liver alone in man and the mammiferous animals, the liver and kidneys in oviparous animals, receive venous blood besides, which explains the nature of the liquids, so different from the blood, and altogether excretory, furnished by these glands. The number and volume, or the total capacity of the arteries, are very different in the glands, but nowhere greater than in the kidneys. The length, course and mode of distribution of the vessels are also very various. The difference of capacity between the arteries and veins is very little discernible in the glands; and, in fact, the greater part of the blood in them is transformed into secreted humour, and conveyed away by the excretory canals.

§ 486. These ducts commence by very fine, invisible, and probably closed radicles, which unite with each other in the manner of the veins, to form several trunks, as in the lachrymal, sublingual and mammary glands, or one alone, as in all the other glands besides. These canals, either many, or single for each gland, generally take a straight course, in the testicles excepted, where it is tortuous, and terminate on the tegumentary membranes. That of the ovary is alone interrupted; those of the mammæ present, before their termination, oval enlargements; those of the kidneys present at first an enlargement or pelvis, and then terminate in a single bladder for both; that of the liver and that of each testicle have also a reservoir, but situated laterally, and to reach which the secreted liquid is obliged to take a retrograde course. The canals of the other glands present neither interruption, enlargements, nor reservoirs.

The composition of the excretory ducts is always the result of a mucous membrane whose thickness diminishes in

proportion as it divides in more minute ramifications in the glands. This membrane is invested externally by cellular tissue, and by an elastic tissue; in some ducts by an erectile one, as in the urethra, in the nipple, and perhaps in some others; in some parts of the excretory passages, the mucous membrane contains muscular fibres.

§ 487. The intimate texture of the glands is little known. Malpighi had advanced that each of the glandular grains, the *acini*, ought to be considered as a follicle, and each gland as a conglomeration of follicles, terminating in a common excretory canal. This opinion was received and admitted without being contradicted until Ruysch, and in his times defended against him by Boerhaave. According to Ruysch, on the contrary, the parts which have been called glandular grains, consisted solely of minute intertwined vessels, in which the arteries should continue and terminate in excretory canals.

In each of these two opinions there are some things true that we must admit, and some parts inexact, that we mustr eject. It is true, as stated by Malpighi, that a gland consists, like a simple or compound follicle, of a canal closed at the extremity; it is true also, as it is affirmed by Ruysch, that each glandular grain, and that the entire gland consists of a mixture and intertwining of minute vessels with the origins of the excretory ducts; but it is as incorrect to say, as he has stated, that the excretory ducts are the continuation of the arteries, as it would be inexact to say with Malpighi, that the radicles of the excretory ducts commence by enlargements or follicles. Perhaps the hypothesis of Malpighi would be more probable if confined to the granulated glands, as the salivary, the pancreas and lachrymal glands, which, in fact, so much resemble compound follicles; and that of Ruysch would more likely be true by applying it only to the liver, the kidneys and testicles, the texture of which is so evidently vascular and canaliculated, without, however, being able to affirm that true hollow follicles exist in the first mentioned organs, and in the others direct continuations between the arteries and the excretory ducts.

In support of this conjecture might be adduced the facility with which, in the latter glands, injections pass from the ves-

sels to the excretory ducts, and vice versa; and the difficulty encountered in obtaining the same results in the lobulated and granulated glands.

However this may be, the texture of the glands seems very positively to result from the intimate association of ramified excretory ducts, closed at their origin, with blood-vessels, lymphatics and nerves, situated in their intervals, dividing and terminating in their thickness; the whole being united by cellular tissue and enveloped in membranes.

§ 488. The function of the glands consists in a mode of secretion which is called glandular. All secretions generally consist in the formation of a particular humour, of which the blood furnishes the materials. Glandular secretion only differs from the others, (the follicular and perspiratory secretions,) by the greater complication of its organs.

With a single exception, the same blood, arterial blood only, is sent into all the glands; the number, the size, the direction, the mode of distribution of the vessels, and the degree of tenuity which they reach by their successive divisions, can only have an influence on the quantity of blood which arrives in the gland, and on the rapidity of its course. However, a part of the blood being brought back by the veins, and another liquid by the lymphatics, the glands pour forth through their excretory ducts, humours as different from each other, as the saliva, the tears, the bile, the urine, the sperm and the milk.

What are then the nature and cause of the conversion of the blood into secreted humours? It has been thought that the change and its cause were purely mechanical, and depend on the size and shape of the openings through which the humours issue from the vessels; it has been supposed with more probability, that it was owing to a chemical change, that is to say, another elementary composition; but this change occurs only in organized bodies, and in some of their organs. This difference is then owing to modifications of their substance, in the same manner as we see different vegetables planted in the same soil, and surrounded by the same atmosphere, produce, some gum, others an acid, others resin, &c. Glandular secretion, like the others, is then a function of the living and

organized substance. The vessels carry to it the materials contained in the blood, the production is even probably disposed or prepared by the arrangement of the vessels and the mode of circulation which results from it; but it is *in the tissue which forms the radicles of the excretory ducts that we must seek for its essential and immediate instrument.* Secretion generally and glandular secretion in particular, are evidently submitted to nervous influence; the effects of the passions on secretions in general, those of diseases, of hysteria, of hypochondria, &c. are sufficiently known. Brodie's experiments have confirmed that which direct observation had taught.

The application of a ligature to the veins of a gland greatly augments its secretion.

§ 489. The first part which begins to be formed in the glands is their excretory duct. In the embryo, this canal is free and floating, as in insects. The glands are afterwards lobate, for instance the kidneys, as they are in the arachnides and crustacea. They are generally very voluminous in the fœtus and in the child. They diminish in proportion as the organs of the animal functions are developed. Some change their situation at the time of birth: these are the testicles and ovaries. These glands and the mammæ are greatly developed at the epoch of puberty and wither in old age.

§ 490. The glands present many individual varieties and vices of conformation. Some are sometimes entirely wanted: those of generation are mostly subject to this circumstance. One of the *double* glands may be wanting or be less voluminous than the other. *Some remain* often lobate, or very voluminous, as in the fœtus. Others are sometimes united as the two kidneys in one. Others may keep their primitive situation, as the testicles and ovaries; these latter are sometimes, on the contrary, protruded out of the abdomen. The kidneys also may be situated a great deal too low, or in the pelvis.

§ 491. We often observe the atrophy of the glands, either in consequence of external pressure, or of an accidental production developed in their thickness: this also occurs for want

of action, or even without an appreciable cause. Hypertrophia sometimes takes place as the effect of the cessation of the action of other organs and especially of a double gland. It is frequently accompanied with some alteration of structure.

§ 492. The inflammation of the glands is common, and often occurs by extending all the way in the excretory canal, from its orifice to its radicles in the gland. Inflammation in them is often suppurative and sometimes plastic; from which results the obliteration of the ducts and the induration of the tissue.

§ 493. Accidental productions, either healthy or morbid, are very common in the glands. The ovaries are most subject to them, but especially to analogous productions; the testicles, the liver and mammæ, are very subject to morbid ones; the lachrymal and salivary glands, and pancreas, are, on the contrary, very little liable, either to the one or to the other accidental productions.

§ 494. Glandular tissue is not produced accidentally. When it is wounded, the radicles or trunk of the excretory duct being divided, the secreted matter is poured into the wound, which has a great tendency to become fistulous and to remain so.

§ 495. Here ends the description of all the systems or kinds of organs which belong especially to the vegetative functions; those which remain to be described belong more particularly to the animal functions. This distinction would be obvious did not one of the tegumentary membranes, the mucous membrane, belong principally to the functions of nutrition and generation; while the other, the skin, is chiefly subservient to the sensations: it is the tegumentary system which unites the two classes of functions and organs.

CHAPTER VI.

OF THE LIGAMENTOUS TISSUE.

§ 496. The ligamentous or desmous tissue, *textus desmosus*, is white, flexible, very tenacious, and forms very solid ties and envelopes.

It has been designated by the names of fibrous, albugineous, tendinous, aponeurotic, &c. tissue. These two latter names, as well as that of ligamentous, have the inconvenience of designating one particular kind of this tissue, and the first, a quality common to many others; for which reason the name *desmous* appears to me preferable, because, although it signifies ligamentous, it has not been applied to the ligaments in particular.

§ 497. The most ancient anatomists, Hippocrates and Aristotle, confounded under the name of nerves all the white parts; hence the names of aponeurosis, syneurosis, ineuration, seminervous muscles, &c. The school of Alexandria, and especially Galen, have positively distinguished the ligaments, tendons and nerves.

Galen and Vesalius had already noticed the analogy which exists between the ligaments and some membranes; Ad. Murray had already indicated the very great resemblance which exists between the tendons, ligaments and aponeuroses. Isenflamm* has given some remarks on this tissue; but it is Bichat, who first considered as a whole every part of this system under the name of fibrous tissue. He comprehended in it the elastic tissue, which I have separated from it, [361.] and ex-

* *Bemerkungen über die flechsen, in Beitrage fur die zergliederungskunst.* Band. i. Leipzig, 1800.

cluded another kind that I have united with it; it is the one which he calls fibro-cartilaginous of the articulations, and the tendinous sheaths in which the tendons slide.

SECTION I.

OF THE LIGAMENTOUS TISSUE GENERALLY.

§ 498. The ligamentous organs do not form a continuous connected whole; a centre and a point of reunion has been sought for all the parts of this system.

A very ancient opinion, anterior to Galen, but announced in one of his treatises, ascribed to the pericranium the origin of all the *nervous* membranes. It has been supposed that the Arabs, in translating into their language the name *meninges* by a word having the same signification, and also that of *mater*, considered the membranes of the brain as generating the other membranes; this is, however, an error advocated by Sylvius, who has represented the meninges as *fecund* and *mothers* membranes. Since Bonn, and recently Clarus, have attributed, in a manner, the same power to the enveloping aponeuroses. Bichat has indicated the periosteum as the central part of the fibrous system. But this system, formed of independent parts, has not, properly speaking, any centre; some of its parts are even entirely isolated from the others. It is, however, a very generally disseminated tissue, having great affinity to the cellular tissue, and in various places continuous with it.

§ 499. The ligamentous tissue presents itself under two principal forms, that of the band or cord, as the ligaments and tendons; and that of membrane or envelope, as the periosteum, the dura mater, the sclerotica, &c. These two forms, funicular and membranous, are confounded in certain parts, which are elongated and rounded at one extremity, expanded and flattened at the other, such are certain tendons; besides, the membranous form, although generally destined to make en-

velopes, sometimes also constitute ties: such are the capsular ligaments, the aponeuroses of insertion, &c. The ligamentous tissue has also been divided, according to its connexions, into the parts subservient to the bones, to the muscles and other organs; and according to its uses, into parts serving for attachments or envelopes, or for both uses.

§ 500. The colour of the ligamentous tissue is white; its aspect is generally shiny or silky.

§ 501. Its texture is essentially fibrous, the fibres composing it are very minute filaments, which are parallel or interlaced. In long and slender tendons, the fibres are as it were braided; in the aponeuroses, they are commonly disposed in several layers crossing each other, and sometimes as it were interwoven. In some parts of this tissue, the fibres are so closely united, that the whole appears homogeneous and not fibrous; such are the cartilaginiform ligaments; but in every other part we may, in dropsical subjects, or in parts which may have been macerated, separate the fibrous bundles from each other, and even the fibres themselves in fine filaments resembling the threads of the silkworm. It is not known if this be the last point of division, but this is probable. These filaments are white, tenacious, slightly elastic, flexible, and probably full or solid. Fontana and Chaussier consider this fibre as being primitive and particular; Isenflamm considers it as being formed of cellular filaments impregnated with gluten and albumen; Mascagni remarks that microscopical inspection seems to demonstrate that these primitive filaments result from a collection of absorbent vessels surrounded by a membrane formed of these same vessels, and of another resulting from very minute blood-vessels making a very fine net-work. We see that this is still the same idea already mentioned above [394.] These filaments appear to be very condensed cellular tissue; maceration softens and changes them into a mucous or cellular substance.

The various ligamentous organs are enveloped in sheaths formed of cellular tissue; moreover, those which have distinct bundles contain also some of this tissue in their interstitial spaces; finally, the fibres themselves are surrounded and bound

together by this tissue, that infiltration and maceration render very apparent. We find adipose tissue also in the thickness of the ligamentous organs. The ligamentous tissue is generally but little vascular; nevertheless, we find at its surface, and we may follow into its substance some small blood-vessels. In order to make them visible, we must, after having injected them with a red injection, dry the part, then dip it in oil of turpentine to render it transparent. Some portions of the ligamentous tissue are very vascular; such especially are the periosteum and dura mater. Lymphatic vessels are perceived in the largest organs of this system. It is doubtful if there be any nerves.

§ 502. The ligamentous tissue naturally contains a great proportion of water. Dessiccation renders it hard, transparent, elastic and brittle; gives it a reddish or yellowish colour, and renders its fibres only slightly distinct. It long resists maceration, which softens and renders it floculent at its surface, separates its fibres, by rendering apparent the cellular tissue in its thickness, and finally converts the fibres themselves into mucous substance. Fire violently crisps it, and leaves behind a large quantity of charcoal. Decoction crisps it very much at first, renders it yellow, hard, elastic, and finally reduces it into gelatin. Cold and warm mineral acids dissolve it: nitric acid commences with crisping it. Cold acitic acid swells and reduces it into a gelatinous mass; when warm it melts it entirely. Alkalies swell and soften it; in this state its fibres separate easily, and present the colours of the rainbow.

§ 503. The elasticity of the ligamentous tissue when fresh is very moderate, but it is strongly marked when dry. Its extensibility is almost null, when the effort is sudden; hence the strangulation produced by ligamentous parts, and the rupture of this tissue by violent distention. But when, on the contrary, the causes of distention act slowly and gradually, the ligamentous tissue yield by becoming thinner and its fibres looser, and if the slow distention be carried too far, they even separate. We must not confound with this phenomenon the augmentation of the volume of the fibrous tissue by excess of nutrition. The retractility of this tissue is proportionate to

the extensibility; it occurs quickly if the distention has been sudden; without, however, producing laceration, and slowly if it has been gradual and slow. The tenacity or power of resistance of this tissue against laceration is very great; it persists in all its energy even after death; the vital irritability and contractility is null in this tissue; therefore we must not admit, with Baglivi, movements of contraction, nor those of oscillation with La Caze. The sensibility of this tissue is extremely obscure and doubtful. Those writers who admit it, confess that it is only developed by certain mechanical agents, particularly for the various parts of this system. Thus the dura mater should be sensible to the impression produced by some excitants, which have no effect on other ligamentous parts; ligaments should be sensible to distention, and to violent pulling which precedes their laceration, while the same thing does not occur in the tendons. Many doubts still exist on this subject. It is wrong, however, to conclude from the experiments favourable to the opinion of the insensibility of the ligamentous parts, that they experience no impression from irritating causes; on the contrary, these causes induce inflammation, morbid sensibility, and diverse alterations in them. The power of formation of the ligamentous tissue is very active.

§ 504. The function of this tissue, entirely mechanical, is to form ties, cords, very solid envelopes, which serve to attach the bones with each other, and the muscles to the bones; to inclose and contain certain parts; to transmit efforts, &c.

§ 505. The ligamentous tissue is at first, in the embryo, soft and mucous like all the other parts; it continues to have, during gestation and infancy, a great deal of softness and flexibility; it is then but slightly dense, more vascular, of a bluish white, with pearly or silvery lustre, and easily soluble in boiling water. Some parts, like the dura mater, the sclerotica and periosteum, are thicker than in the adult; the tendons and aponeuroses, on the contrary, are more slender and thinner. In old age, on the contrary, it becomes yellow, has less lustre, is firmer, more coriacious, dryer, less vascular, and less soluble in boiling water than it is in the adult.

Notwithstanding the firmness of the ligamentous tissue in

old persons, it has not a very great predisposition to ossification. The tendons are seldom ossified except where they rub, and where they have a fibro-cartilaginous texture, and at their extremity where inserted into the bones. The rare occurrence of senile ossification of the tendons is so much the more remarkable, as in various animals, as certain birds, or as the insects and the crustaceæ, ossification or an analogous induration always occurs in the regular development of these parts.

§ 506. The different parts of the fibrous system, although sufficiently analogous to form one kind of organs, they are not, however, identical; the texture of the tendons is less close than that of the ligaments, that of the cartilaginiform ligaments is so compact, that it appears almost homogeneous. The chemical composition of all these parts is nearly the same; the tendons yield, however, much more easily to the dissolving action of boiling water, than the other ligamentous parts.

§ 507. The ligamentous tissue, when divided, torn or lacerated, reunites: this we see occurring in the ligaments after luxations. The tendo achilli, or some other large tendon being lacerated, if the ends are kept motionless and in contact, there occurs at first an agglutination between them, then an organic reunion which, more extensible at first than the tendon, acquires in time its force of cohesion, or its tenacity and its almost inextensible character. There takes place between the extremities of divided muscles, and sometimes after the fractures of bones, fibrous reunions.

§ 508. The accidental productions of the ligamentous tissue is pretty frequent, and presents itself under several forms. We find membranes of this kind around certain cysts which are, however, seldom altogether enveloped by it. Some solid tumours have also envelopes of the same kind. Preternatural joints have also fibrous capsules more or less distinct. We sometimes find fibrous bands in the serous membranes, and especially in the pleura.

The isolated fibrous or ligamentous bodies have been very anciently observed, but confounded with schirrhus; M. Chambon has described them under the name of scleromes. Walter and Baillie were acquainted with them. Bichat, and after him

M. Roux, have described them; but it is to Bayle and to Laennec that we owe our complete knowledge of them. They have a globular form, their surface is unequal and as it were lobated; the largest anfractuosities contain vessels and infiltrated cellular tissue. When split they are seen to be formed of lobules and convoluted bands, connected by cellular tissue, and of fibrous prolongations. They have few vessels internally. They are at first small and soft like the fibrine of the blood; they progressively increase in size and change their texture; they seldom become cartilaginous, but frequently osseous; an ossification of a strong hardness is developed in them in an irregular manner, and resembles in their thickness to a mulberry calculus. They are often formed in the texture and near the surface of the uterus; sometimes in the ovary, in the accidental cellular tissue of the serous membranes, and are then formed of layers like a bulbous root, in the cellular tissue; and it has been said in the bones also; they have been seen in the fingers and eye-lids, under the mucous membrane of the nose; the fungi of the dura mater are sometimes bodies of this kind; once they have even been seen in the brain.

Irregular fibrous productions are found in the cicatrices of the liver, bones and skin; in the scrotum and elsewhere around fistules.

§ 509. There is a production which comes very near the ligamentous tissue: it is that of a white compact tissue, not fibrous, nor laminar, nor cellular, semi-transparent, not chatoyant, soft and tenacious. Some organs in a state of atrophy, appear to be transformed into this tissue; the cicatrices of the skin, that of the cellular tissue after the cure of chronic-phlegmous, and after that of old fistulæ, and some white granulations of the serous membranes, resembling the glands of pachioni, are of this kind.

There should also be referred to it, the sclerosis which is observed in the cellular tissue and the skin in elephantiasis of the limbs, scrotum, and vulva, and which has also been seen in the subperitoneal cellular tissue, in a case of cancer.

It is to this production that we must also refer the greater number of the polypi of the uterus and especially of the va-

gina, and some tumours projecting under the skin; polypi and tumours, whose white, compact, soft and tenacious tissue, differs from the fibrous tissue, but bears more resemblance to it than to any other.

These varieties of accidental white tissue have somewhat a slight resemblance to morbid productions by their tendency to spread and to reappear.

§ 510. The inflammation of the ligamentous tissue is little known, but is not of very rare occurrence.

It most frequently terminates by resolution, often also by the production of a plastic or organizable matter, which is sometimes absorbed, and at others gives rise to accidental ossification. Chronic inflammation softens this tissue, causes it to lose its tenacity, and sometimes also gives rise to its ossification.

Some fungus of the dura mater contain polypi of the nasal fossæ, and posterior parts of the nostrils, certain *epulies*, some tumours of the periosteum, are morbid productions or cancerous degenerations of the ligamentous tissue.

SECTION II.

OF THE LIGAMENTOUS ORGANS IN PARTICULAR.

§ 511. Overlooking for the present the fibro-cartilaginous tissue, the fibrous organs may be divided into those which bind the bones with each other, those which attach the muscles to the bones, and those which form envelopes.

ARTICLE I.

OF THE LIGAMENTS.

§ 512. The ligaments,* *ligamenta nervi colligantes*, σύδεσμοι, are the fibres which connect the bones and cartilages with each other.

* Jos. Weitbrecht, *syndesmologia sive historia ligament. corp. hum. &c. tum figuris*, 4to. Petropol. 1742.

The same name has improperly been given to many other parts and especially to bridles formed by folds of the serous and mucous membranes, to serous and adipose prolongations, &c.

The true ligaments are attached by their two extremities to the bones and periosteum, and so firmly, that in the adult, it requires an advanced stage of putrefaction to separate them; but in children they separate from the bones with the periosteum by a moderate maceration.

The fibrous tissue which enters into their composition is very dense, and arranged in more or less distinct bundles, very closely connected; some go even so far as to have the apparent homogeneous structure of the cartilages.

By decoction, they are resolved, though with difficulty, into gelatine and albumen.

§ 513. The ligaments are often affected with inflammation, either through mechanical causes, as those of sprains and fractures in the articular parts of the bones, or through the inflamed neighbouring synovial membranes, or through the specific causes of articular rheumatism and gout. Inflammation gives rise to two different effects in the ligaments: namely, an extreme softening and a loss of their power of resistance, or accidental ossification. This last change is the most frequent; the other is especially observed in the scrofulous diseases of the articulations.

According to their connexions and uses, the ligaments are distinguished in articular, non-articular, and mixed. The first are those which are attached by their extremities to different bones that they connect, these are the most important; the second kind are those, which attached to different parts of the same bone, serve to close notches, as at the orbital arch and at the superior margin of the scapulæ, or to close an opening and give attachment to muscles, like the obturator ligament of the foramen ovale; the last are those which, like the sacro-ischiatic and interosseous ligaments of the arm and leg, are fixed to different bones, but serve especially for the insertion of muscles.

The articular ligaments are distinguished into capsular and funicular.

The capsular ligaments or fibrous capsules consist of cylindroid ligamentous sheaths which surround the articulation, which are fastened by their two extremities to the two articulated bones, and are lined internally by the synovial membrane. These capsules, while they firmly connect the bones, allow of motions in all directions. They are almost peculiar to the scapulo-humeral and coxo-femoral articulations; however, rudiments of them are to be found in some others, in which irregular bundles strengthen the synovial membrane in several points of its contour.

The cords or ligamentous bundles of the articulations are rounded strings or flattened bands, mostly situated outside of the joints, and few of them only in the articular cavities. Both permit movements in some directions, but prevent or limit them in others.

The external ligaments are mostly placed at the two sides of the articulation, and for this reason are called lateral ligaments; many moveable articulations are provided with them; others are anterior and posterior; some, in consequence of their direction, are called crucial ligaments. All these ligaments, which are attached by their two ends to the bones, correspond by one of their faces to the synovial membrane, and by the other to the surrounding common cellular tissue, muscles and tendons.

The internal ligaments are surrounded by a sheath furnished by the synovial membrane, which is reflected at their two extremities [212].

ARTICLE II.

OF THE TENDONS.

§ 515. The ligaments of the muscles or the tendons,* *tendines*, τένοντες, are ligamentous parts to which are attached the extremities of the muscular fibres.

* Albinus, *annot. acad.*, lib. vi., cap. 7, et tab. 5.

Among the tendons, some are funicular, and have the form of an elongated, rounded or flattened, but narrow cord, these are the tendons properly so called; the others are expanded and membraniform, those are the aponeurotic tendons or the aponeuroses of attachment.

Both are chiefly placed at the extremities of the muscles, and serve to insert them; the others, placed lengthwise and interrupting the fleshy fibres, are tendons and aponeuroses of intersection or enervations.

Among the tendons of insertion, there are even some, which consisting in a multitude of small isolated fibrous bundles, have neither the form of a cord nor of a membrane.

There are others which form arches attached by their two extremities, and under which vessels pass; such is the one under which pass the femoral vessels to become poplitcal, &c.

Among the tendons there are some which have the form of a cord in the greater part of their length, and which, at one of their extremities, or both, expand into membranes.

There are others which are simple at one extremity, and divide at the other into several cords or into laminæ of greater or less breadth.

The connexion of the tendons with the muscular fibres is very firm; it has even been asserted that there are a real continuity and identity between these parts. But, besides the difference of density and colour, besides the remarkable difference which is perceived with the microscope between the two tissues, we remark aponeurotic tendons whose fibres have a different direction from those of the muscles; the tendons are moreover much less vascular than the muscles; they are proportionally longer in children; they separate from the muscles by decoction; they are resolved into cellular tissue by maceration; they are not irritable like the muscular fibres, &c.; they are not the continuation of the latter, but simply that of the cellular tissue of the muscles.

By the other extremity the tendons are attached to the bones, and generally near the articulations. Some aponeurotic tendons, instead of directly attaching themselves to the

bones, expand and are confounded with the envelopes of the muscles.

The tendons are surrounded with common and lax cellular tissue, or with mucilaginous bursæ, according to the extent of the sliding they experience.

Some are kept in their respective places by rings or sheaths.

The colour of the tendons is white, shining, bordering on a green, silky or velvety.

The fibrous tissue which composes them contains in its interstices, in the largest at least, some cellular tissue, and small sanguineous vessels.

Some tendons have a fibro-cartilaginous texture; they are those which rub against the bones. They even, in time, become bony at these points.

Their essential properties are inextensibility and force of cohesion, which renders them well calculated to transmit to the bones the action of the muscles, the only function they have to perform.

They are seldom altered; puncture induces in them an indolent swelling which is slowly resolved.

ARTICLE III.

OF THE LIGAMENTOUS ENVELOPES.

§ 517. The ligamentous membranes furnish to certain parts, envelopes analogous to those that the cellular tissue forms about certain other organs. These membranes are the following:

A. OF THE ENVELOPES OF THE MUSCLES.

§ 518. The envelopes of the muscles, or the enveloping aponeuroses also furnish, in some places, insertions to the muscular fibres; they are of two kinds, some surround the muscles of the members, others invest those of the parietes of the trunk.

§ 519. The enveloping aponeuroses of the limbs, *fasciæ musculares*,* are ligamentous membranes which surround the

* Ad. Murray, *de Fasciæ latâ*. Upsal, 1774.

muscles of the limbs and binds them down to the bones. These membranes have the form of sheaths; their external surface corresponds to the cellular and adipose tissues, as well as to the subcutaneous vessels and nerves. Their inner surface corresponds to the muscles, furnishes attachments to some of them, sends laminæ between the greater number of them, partitions, prolongations which separate them from each other, which furnish attachments to them, and terminate by inserting themselves on the ridges and lines of the bones. Their extremities are attached to the bones, receiving insertions or expansions of the tendons, losing themselves insensibly in the cellular tissue, and in other places forming annular ligaments to the tendons. They consist of one or more layers of ligamentous tissue of variable thickness, and are proportionate in their thickness to the number and strength of the muscles that they embrace; they present openings for the passage of vessels from the deep to the superficial plane and *vice versa*. They are provided with tensor muscles, either proper, or simply by the expansion of their tendons. Their uses are to keep the muscles in their proper places, and to furnish them with points of attachment. They exercise by their resistance a slight pressure on the deep vessels, and thus favour the venous and lymphatic circulation. Their knowledge is of great importance in a pathological point of view, on account of the strangulations which they may induce; nor is its knowledge less so in surgery, in consequence of their relations with the muscles and vessels.

The thigh, the leg, the foot, the hand, the fore-arm and arm, are provided with aponeuroses of this kind.

§ 520. The aponeuroses of the parietes of the cavities of the trunk, or the partial aponeuroses, invest, cover, and even envelop, at least in part, certain muscles: such are the compound aponeurotic sheaths of the recti and pyramidales muscles of the abdomen; the dorsal aponeurosis which covers the muscles of the vertebral grooves; the temporal aponeurosis; the pelvic, transversal, superficial, jugular aponeuroses, &c. Some, and especially the latter, are not very distinct from the cellular tissue, into which they are continued.

B. OF THE SHEATHS OF THE TENDONS.

§ 521. The sheaths of the tendons are ligamentous canals which embrace and fix the tendons in their place.

Some of them are sufficiently long to form true canals; others, which are much shorter, are called annular ligaments. Some of these annular ligaments are entirely circular; others, as well as the sheaths, are completed by the neighbouring bones, whence result osteo-ligamentous sheaths. They are, together with the tendons which they contain, invested by vaginiform synovial membranes. These sheaths are very solid and strong; they contain each one or more tendons; they are especially more numerous at the free extremities of the limbs, more in the direction of flexure, and also stronger in this direction than in that of extension. They keep the tendons in their proper place, prevent their displacement during the action of the muscles and the motions of the joints; they also serve, in some places, as pulleys which change the direction of the tendons and modify that of the motions.

C. OF THE PERIOSTEUM.

§ 522. The envelope of the bones, or the periosteum, embraces the bones in their whole extent, excepting the articular surfaces. The teeth alone, which however are not bones, are destitute of it.

This envelope is interrupted at the amphiorthrodial and diarthrodial articulations, but is not so at the immoveable ones.

Its external surface is flucculent, and nearly covered with filaments which confound themselves with the surrounding cellular tissue, and which, in other places, are continuous with the ligaments and tendons.

The internal surface is fixed to the bone by innumerable prolongations which accompany the vessels into its interior and into its substance. This surface is very firmly attached to the bones wherever they are thick and spongy, but less so in the other parts. Its adhesion is also less firm in children than in adults.

The thickness of the periosteum is variable, and proportionate to the vascularity of the bones.

Its texture is fibrous, and fibro-cartilaginous in the places where the tendons rub. It has very numerous blood vessels,* and in this respect forms a remarkable exception in the ligamentous tissue. Lymphatic vessels have also been observed in it, but no nerves.

The periosteum is at first thin and has little vascularity before the period of ossification. It becomes thick and vascular at this time. The use of madder does not colour it.

The functions of the periosteum are to envelop the bones, support the vessels, unite the epiphyses, in childhood, to the body of the bone, and to serve at this period to insert the ligaments and tendons.

The formation of bone has been ascribed to it, but without any proof; for the ossification of the short bones is observed to begin at the centre of the cartilage, and therefore far from the periosteum; and also of determining the form of the bones, of limiting their growth by retaining the osseous humour, &c. As to the part it may perform in the increase of the bones in thickness, in the repairing the fractured bones or affected with necrosis, will be examined hereafter, (*chap.* viii.)

The periosteum, when divided, reunites; when it is removed a superficial necrosis is commonly produced, and it is reproduced after exfoliation. When it is inflamed, sometimes is terminated by resolution, at others by gangrene; sometimes it suppurates, and then separates more or less quickly from the bone, which becomes affected with necrosis; at other times, the inflammation being plastic, a deposition occurs in its thickness, producing a *periostosis*, which is sometimes dispersed by absorption, and at others ossifies. The periosteum is frequently the seat of a degeneration or of a cerebriform cancerous production, at the centre of which the bone itself is not very materially altered.

§ 523. The perichondrium, a ligamentous membrane which

* *See* Ruysch, *adv. anat. dec* iii. tab. ĭi. fig. 8.—Albinus, *Icon. oss. fœtus.* Tab. xvi. fig. 162.

envelops the cartilages, differs only from the periosteum by being less vascular. It fulfils, with respect to the cartilages, the same functions as the periosteum with reference to the bones, and moreover, it imparts to those which are thin and flexible, a power to resist rupture, and a tenacity which they do not of themselves possess.

D. OF THE FIBROUS ENVELOPES OF THE NERVOUS SYSTEM.

§ 524. The nerves have a peculiar envelope, the *neurilema*, which is of the same nature as the ligamentous tissue. Around the spinal marrow, this envelope loses the firmness of the ligamentous tissue, and around the brain, where the piæ-mater is its continuation, it becomes simply cellular and vascular. The neurilema, much less vascular than the piæ-mater, is still a very vascular part of the ligamentous system.

§ 525. The dura-mater or menix, which is vascular like the periosteum, differs from this common membrane of the bones, in being lined by the arachnoid, which converts it into a fibro-serous membrane, because it forms a coat or capsule to the brain and spinal marrow, in as much as in the cranium, the only place where it also serves as a periosteum, it contains sinuses or venous canals in its thickness, and forms prolongations or portions between the divisions of the brain.

E. OF THE COMPOUND FIBROUS MEMBRANES.

§ 526. The pericardium and perididymes or tunica vaginalis are, like the dura-mater, fibro-serous membranes, being the result of the intimate union of ligamentous membrane with the external or parietal layer of a serous membrane.

In the nasal fossæ and their sinuses, in the cavity of the tympanum and mastoid cells, at the roof of the mouth and in some other places also, the periosteum is immediately covered by a mucous membrane which is intimately united to it, which constitutes a fibro-mucous membrane.

These compound membranes resemble, in their texture, functions, and alterations, the two kinds of tissue of which they are formed.

F. OF THE FIBROUS CAPSULES OF SOME ORGANS.

§ 527. Finally, the eye is contained in a capsular membrane called sclerotica and cornea; the testicle in one which is named albuginea, both remarkable for their thickness and firmness. The ovaries, the kidneys, liver, and some other parts, have envelopes of the same kind, but not nearly so thick or solid. Most of these capsules, in fact all of them excepting the sclerotica, have fibrous internal prolongations which extend into the tissue of the organ. They are perforated by some openings for the passage of vessels, but have very little vascularity themselves. Their common uses are to determine the form of the organs which they envelop, contain, support, and protect their internal parts.

SECTION III.

OF THE FIBRO-CARTILAGINOUS TISSUE.

§ 528. The fibro-cartilaginous tissue is fibrous and tenacious like the ligamentous tissue, of which it really forms a part; white, very dense and elastic, like the cartilaginous tissue, it seems intermediate between the ligaments and cartilages.

§ 529. Galen has named certain ligaments neurochondroid νευροχονδρωδες συνδεσμοι; Vesalius calls them cartilaginous ligaments; Morgagni considers them as intermediate between the ligaments and cartilages; Weitbrecht comprehends them among the ligaments; Haase, on the contrary, classes them in the chondrology, under the names of ligamentous and mixed cartilages. Bichat has established a fibro-cartilaginous system, composed of the cartilaginiform ligamentous tissue of which we here speak, and of a part of the cartilaginous tissue, which will be described in the next chapter; but this system of organs does not appear to me to exist in nature, for which reason I have rejected it. The fibro-cartilages, of which we speak,

seems to me to be but a variety of the desmous tissue: they are cartilaginiform ligamentous organs.

§ 530. The fibro-cartilages are either temporary or permanent.

The temporary fibro-cartilages are those which pass regularly, constantly, and at determinate epochs into the osseous state: they are the fibro-cartilages of ossification. They are found in the substance of the tendons and ligaments. They are purely fibrous in the beginning, afterwards become fibro-cartilaginous, and finally osseous. The patella and sesamoid bones are developed in this manner. The places where the tendons rub against the bones, those, for instance, where the gemini are applied on the femur, and where the peronæus lungus lateralis slides on the tarsus, are also constantly the seat of fibro-cartilages of this kind. The stylo-hyoid and thyro-hyoid ligaments contain grains of the same nature in their substance. The sclerotica, in certain animals, presents opaque spots, equally fibro-cartilaginous, which afterwards form bony plates.

§ 531. The permanent fibro-cartilages, or at least those which remain during the greater part of life, are of several species. 1st, There are some which are free at their two surfaces: these are the inter-articular ligaments, *menisei;* they are met with in the temporo-maxillar and sterno-clavicular articulations, sometimes in that of the acromion with the clavicle, always between the femur and tibia, and between the ulna and pyramidal bone. These ligaments, perfectly isolated at their two surfaces, adhere by their edges or by their extremities. 2d, Others adhere by one of their surfaces; such are those which are found wherever a tendon rubs against a bone, and the presence of which is owing to the circumstance that the periosteum becomes cartilaginous in these places; and those the ligaments present, against which slides the tendons, as is the case for the calcaneo-cuboidal ligament, against which the tendon of the tibialis posticus rubs. Such are also the fibro-cartilaginous roundish borders attached to the margin of the glenoid and cotyloid cavities. Generally, wherever the fibrous tissue is exposed to continued frictions, this tissue assumes a

cartilaginous texture or appearance, as is observed at the annular ligament of the wrist, and the transverse ligament of the odontoid process of the second vertebra; the pulley of the obliquus major muscle also affords an instance of the same kind. 3d, Certain cartilaginous ligaments adhere by their two surfaces; the intervals between the bodies of the vertebræ and the interval between the two ossa pubis, are filled up with organs of this kind. Thus, according to their form and connexions, there may be distinguished three kinds of cartilaginiform ligaments.

§ 532. These organs, although always fibrous like the ligaments, and very dense like the cartilages, present a great number of varieties, with reference to the consistence and homogeneousness of their tissue. The *minisei*, or inter-articular ligaments, for instance, present very distinct fibres at their circumference, and towards their centre, which is thin, an appearance more and more compact and homogeneous, without, however, meriting, even in that place, the title of true cartilages. The cartilaginous periosteum has more resemblance to these latter. In the amphiarthrodial ligaments, a very apparent fibrous tissue exists at the exterior. In proportion as it approaches the centre, it becomes converted into a kind of pulp or white pap which resembles cartilage, less in its consistence, however, than from the disappearance of the fibres and its apparent homogeneousness.

§ 533. There enter into the composition of the fibro-cartilages the same parts as into that of the ligamentous tissue: few vessels occur in them. Their chemical composition has been but little studied. They become yellow and transparent like the ligaments, by desiccation. Decoction acts on them in the same manner as on these latter; they are entirely melted by it into a jelly, so that they do not, in this respect, participate of the nature of the cartilaginous tissue.

§ 534. Their physical properties are similar to those of the ligaments and cartilages. Their tenacity or force of cohesion, which is very great, and even exceeds that of the bones, approaches them to the ligamentous tissue. On the other hand, they are very elastic, and quickly return on themselves when

they have yielded, either to distention or to pressure; it is particularly when they are compressed that their elasticity is most remarkable. They resist more than the bones and cartilages, the destructive action of pulsatile tumours. In aneurisms of the aorta, the vertebræ are worn and destroyed before the fibro-cartilage which separates them. This property is a consequence of their elasticity. The vital properties of the fibro-cartilages are obscure, like those of the ligamentous tissue generally.

§ 535. In their formation, several of these parts pass through the fibrous state; others pass directly from the mucous to the fibro-cartilaginous state. It is only accidentally, and in a variable manner, that the permanent fibro-cartilages become bony in old age; this, however, occurs more frequently to them than to the ligaments, but less frequently than to the cartilages.

§ 536. The temporary fibro-cartilages have for use to serve as a type or mould to bones. Those which are permanent, sometimes form flexible, elastic, and very firm bonds, and sometimes serve to facilitate slidings, by the consistency which they give to the surface.

§ 537. The morbid states of the fibro-cartilages are little known. They unite again after being divided, as is observed after the operation of symphyseotomy.

Their accidental production is not of very rare occurrence. The centre of an intervertebral ligament may be taken as the type of the species, and as an object of comparison. The accidental fibro-cartilages are, in fact, fibres, like the ligaments, of a milky white like the cartilages, pliant, moist and elastic. According to their form, connexion and uses, the accidental fibro-cartilages may be divided into two kinds. Some are the means of union of certain fractures which have not been consolidated, either on account of motions, like those of the neck of the femur, the patella and others, or on account of an extensive loss of substance in one of the bones of the fore-arm, leg, metacarpus, skull, &c. places where the fragments can not be brought together. Other fibro-cartilages are formed on the extremity of amputated bones, on the surfaces of supernume-

rary articulations, on and about the surface of the supplementary articular cavities, and in some false anchyloses. Some shapeless fibro-cartilages are found in some compound tumours of the thyroid body, in certain cysts, and in some cicatrices, especially those which occur in the lungs, after discharge of tubercles. Layers of the same kind are found at the surface of the spleen. The fibrous bodies of the uterus are sometimes soft and pulpy at the centre, like the intervertebral ligaments. Finally, we sometimes find globular and regular fibro-cartilaginous masses, which freely float in the serous cavity in which they penetrate. Dr. Trouvé, of Caen, gave me a tumour of this kind, as large as a walnut, which was found, together with another of the same nature, in the peritoneal cavity. This tumour, which is distinctly fibrous at the exterior, is soft like the intervertebral ligaments towards the centre, and contains in this place a bone of the size of a pea.

§ 538. The inflammation of the fibro-cartilages has been but slightly observed. All we know is, that in certain cases, the desmo-cartilaginous parts become extremely soft in consequence of an afflux of fluids, that is, by a kind of congestion. This is observed in gestation, at the symphysis of the pelvis, and which has been observed even in man, in the same articulations. The vertebral column presents this softening in a very marked degree in cases of rachitis. There results from it a flexibility of the intervertebral ligaments, which makes the column bend with the greatest facility, and should the individual keep himself habitually in an improper attitude, causes the spine to bend laterally in several places, and ultimately involves the vertebræ themselves in the deformity.

One of the varieties of the vertebral diseases also consists in the softening and swelling of the intervertebral ligaments, which at length ulcerate and are destroyed.

CHAPTER VII.

OF THE CARTILAGES.

§ 539. The cartilages Χόνδροι, are white, hard, flexible, very elastic, brittle parts, apparently homogeneous, which form the skeleton of the vertebrate animals lowest in the series, (the chondropterygious fishes); which in the beginning of the life of other vertebrate animals fulfil the functions of bones; some of which remaining in the adult age, form parts which are solid, hard, and flexible at the same time.

§ 540. The old anatomists and those of the Italian school, disputed much respecting the matter which forms the bones and cartilages, and about their differences; Galiardi and Havers in vain sought for this difference in the intimate texture of the parts. More useful observations have been made in the last century on the cartilaginous tissue. We are indebted to Haase* for a very good dissertation on this subject; but this anatomist, like several of those who preceded and followed him, has confounded the condroid ligaments with the cartilages, which renders his general description rather vague. Bichat has separated from the other cartilages those which are thin and very flexible, to form together with the cartilaginiform ligaments, the fibro-cartilaginous system; but these latter are in fact ligaments, and the former true cartilages.

§ 541. The cartilages are either temporary or permanent: the former constantly, completely and regularly disappear at a determinate period of their growth, and are replaced by the bones; the latter remain a much longer time, and sometimes more than a century, in the cartilaginous state; however,

* J. G. Haase, *de Fabrica cartilaginum*. Lips. 1767.

several of them, at least ossify, sometimes even at the end of the period of growth. The temporary cartilages will be described along with the bones, (*chap.* viii.) We shall treat here only of the cartilages called permanent: they form a very natural genus of organs, and present also some differences.

SECTION I.

OF THE CARTILAGES IN GENERAL.

§ 542. Some cartilages have an elongated form: such are the cartilages of the ribs; others are thick and short, like the arythenoid and cracoid cartilages; but the greater number are broad and thin.

Some are attached to the bones of which they cover certain parts; others are prolongations of them and are firmly united to them; others are connected to the bones by ligaments; others are attached to each other, and have no other connexions with the bones.

The cartilages are of a pearly white, and semi-transparent when in their laminæ; although they are the hardest parts of the body after the bones, they are easily cut.

§ 543. The cartilages, when examined in their substance, present neither cavities, nor canals, nor areolæ, nor fibres, nor laminæ, finally, nothing that indicates an organic texture; they appear homogeneous. It seems, however, that they have a distinct and different kind of texture in each species of cartilage: this assertion will be investigated hereafter.

All the cartilages, with the exception of those of the articular surfaces, are enveloped in a fibrous membrane, the perichondrium, which has few vessels, and is not so intimately connected with the cartilages as the periosteum is with the bones. Neither nerves nor vessels have ever been discovered in the cartilages; the cellular tissue is not apparent during life, and after death they require to be macerated during several months, even with young subjects, to reduce them to a mu-

cous substance analogous to the cellular tissue, and which, in their ordinary state, must be an extreme degree of compactness and condensation.

§ 544. Cartilages contain a great quantity of water* or serous liquid, which oozes at the surface when it is cut, and which moistens it. In the adult man the proportion of water that they contain is to the solid substance as 2¼ is to 1. Dried cartilages become semi-transparent, yellowish, and susceptible of being torn; steeped in water it resumes in four days its weight and volume, its white colour, its flexibility, and partly loses its transparency.

§ 545. Submitted to the action of boiling water when in thin laminæ, it at first crisps them and renders them yellow and opaque.

The prolonged action of the boiling water on cartilages establishes between them a difference founded also on other character; the cartilages of the joints are reduced into a jelly by decoction, the other, on the contrary, resist its action. Alcohol renders cartilages slightly opaque. Diluted acids have no action upon them; when concentrated, they act as upon the epidermis. Their chemical analysis is as yet imperfect. It has been vaguely repeated, after Haller, that they are composed of gelatine and earth. According to M. Allen, they are composed of gelatine, and a hundredth of carbonate of lime. Hatchett says that they are formed of coagulated albumen and traces of phosphate of lime; but we do not know to which cartilages he alludes. M. Chevreul has found that the cartilaginous bones of the shark (*squalus*) are composed of oil, mucus, acitic acid, and some salts. J. Davy has found cartilages formed of albumen 44, 5; water 55; and phosphate of lime 0, 5.

§ 546. The physical property the most remarkable of the cartilages is elasticity. They do not elongate and return on themselves, like the elastic tissue; they generally do not yield to pressure, like the chondroid ligaments, and afterwards resume their thickness; but they are flexible, and return to their

* Chevreul, *de l'influence que l'eau exerce, &c. Annales de Chimie et de Physique*, tome 19.

general former state with force and celerity whenever the cause of flexion ceases to act. The articular cartilages alone are elastic in the same manner as the fibro-cartilaginous tissue.

§ 547. The vital properties and phenomena of formation, irritation and sensation, are extremely obscure in the cartilaginous tissue. It is not known if the pain felt in the articulation, and caused by foreign bodies when between the two surfaces, is to be ascribed to the articular cartilages, or rather to the synovial membrane which invests them.

§ 548. The functions of the cartilages depend solely upon their physical properties; upon their firmness, which enables them to preserve the shape of certain parts; upon their flexibility and elasticity, which permit them to yield, at times, and resume afterwards their former state.

§ 549. The cartilages in the embryo and fœtus, are at first soft, mucous and transparent, like jelly or glue; the proportion of water at this time is very great; in the child, they are yet slightly coloured, very transparent, very soft, and slightly elastic. They afterwards become white, acquire firmness, and the semi-opacity which characterizes them. Later, in old age, they become whiter or yellower, more opaque, less flexible, less elastic, more brittle and drier; the proportion of water diminishes, and that of the earthy substance increases. They at last ossify, at least in some points. This alteration commences sometimes as soon as the adult age, but especially in old age. Inflammation prematurely determinates this change.

§ 550. The organic action of nutrition seems to be very slow in it. The use of madder does not colour them; that substance appears to have affinity only with the earthy substance of bones. They become yellow in jaundice. The cartilaginous bones of the vertebral column of the lamprey appear and disappear every year, from which they must be inferred to possess a great organic activity, which is also the case with the rapid growth of the larynx towards the period of puberty.

§ 551. Accidental cartilaginous productions are very common, they have all the characters of natural cartilages: colour, apparent homogeneity, &c. They present all the varieties of texture of the cartilages, and even more; we must therefore

divide them into two kinds. The imperfect accidental cartilages are sometimes in the state of jelly, or have the consistence of the boiled white of egg. They have a milky, or yellowish, or pearly-gray colour; they are partially or totally ossified, rather than becoming perfect cartilages. They are met with under the form of incrustations in the arteries, and especially in the aorta and in the cerebral arteries; under the form of cysts around morbid productions and acephalocysts; forming the fistulous passages in the lungs; under the form of irregular masses in goitres, and other compound tumours, and under that of isolated bodies in the articulations.

The perfect accidental cartilages are those which present the character of the natural tissue, and especially its firmness. Some are found forming small cysts filled with phosphate of lime. Some are sometimes met with in the state of isolated bodies, of a moderate volume of an obround figure, in the synovial membranes, or at their exterior, whence they penetrate into the cavity by pushing the membrane before them, enveloping itself as with the finger of a glove whose base, after becoming very thin, separates. They imperfectly ossify either in part or in totality, but beginning in the centre. These cartilaginous bodies are also found in the splanchnic cavities, and especially in the tunica vaginalis, into which they penetrate like those just described.

Perfect cartilages also occur under the form of incrustations or plates, in the sub-serous cellular tissue of the spleen, the lungs, and the pleura costalis, in the substance of the valves of the heart, especially in the left side, in the sub-serous tissue of the diaphragmatic pleura and peritoneum, and in that of the liver in herniæ, and seldom in the anterior parietes of the abdomen. All these incrustations have a great tendency to ossify. Cartilages also happen in shapeless masses in the compound tumours, under the accidental cellular tissue of the serous membranes.

Accidental cartilages are sometimes formed by transformation of other tissues. An old woman who some years ago was at the Hospital of the faculty of medicine at Paris, and who had on her forehead a broad conoid horny production

which grew on the cicatrix of a burn, having died, the bones of the skull immediately under this horn were found to be transformed into cartilages. Laennec saw a cartilaginous transformation of the mucous membrane of the urethra. I have observed the same thing in the vagina, in a case of prolapsus uteri, and in the prepuce, in a case of congenital phymosis, in an old man. I am at the same time of opinion that these three cases belong rather to the desmo-cartilaginous productions.

§ 552. Alterations* of the cartilages are rare and most commonly consecutive. They resist for a very long time the destructive action of aneurismal tumours, and the propagation of diseases of the neighbouring parts. The alterations to which they are subject, and the reparation of their injuries, are somewhat different in the various kinds of this tissue.

SECTION II.

OF THE DIFFERENT KINDS OF CARTILAGES.

§ 553. The cartilages may be divided into three principal kinds, with respect to their form, connexions, texture, properties and functions.

ARTICLE I.

A. OF THE ARTICULAR CARTILAGES.

§ 554. The diarthrodial articular cartilages† are flat and broad cartilaginous laminæ, which tip or invest the surfaces of the bones in the moveable articulations. These laminæ

* Doerner, *præside* Autenrieth, *de Gravioribus quibusdam cartilaginum mutationibus*. Tubing. 1798.

† W. Hunter, *Of the structure and diseases of articulating cartilages;* in Philos. trans. 1743.—Delasone, *sur l'organisation des os; mém. de l'acad. des sci.* Paris, 1752.

have a free surface, covered by the synovial membrane which is closely attached to it, and a surface which also adheres intimately to the surface of the bone, without a continuity of tissue however existing between them. Their circumference, which is thinner than the rest, extends to that of the articular surfaces of the bones. Their thickness, which is inconsiderable and proportionate to their breadth, is from one to two lines in the largest, and a fraction of a line in the smallest. It is not the same in the whole of their extent. Those which incrust or tip convex bony surfaces are thicker at the centre than in the remainder of their extent. Those of the concave surfaces, on the contrary, are thicker at the circumference than at the centre.

§ 555. The texture of these cartilages is at first sight as indistinct as that of the others, so that they resemble a layer of wax spread over the bone, but may be discovered by certain modes of procedure. It is fibrous. Maceration of an articular part of a bone, continued for six months, effects the destruction of the synovial membrane, the only membrane covering the cartilage which is destitute of the fibrous perichondrium, and produces disunion of the fibres of which it is composed, which rise perpendicularly from the surface of the bone like the pile of velvet. If a cartilage thus disposed by maceration be dried, the fibres become smaller and thus separate from each other, becoming more distinct. Decoction, when not prolonged so as to dissolve the cartilage, produces at first the same effect as maceration. The action of fire also discloses the structure in the same manner. These cartilages have no vessels. Delicate injection and microscopic inspection show the capillary vessels terminating at their circumference and at their adherent surface, without ever penetrating into their substance.

These cartilages, which are compressible and elastic, deaden the effects of pressure and concussions. The smoothness of their surface facilitates the motion of the diarthrodial articulations. They become much thinner in old age.

§ 556. In preternatural joints, no true cartilages are produced, but only desmo-chondroid tissue, a tissue which, in

truth, greatly resembles that of the diarthrodial cartilages. In the natural diarthrodial articulations, the destruction of the cartilages is sometimes followed by their nearly perfect reproduction; only the new cartilage produced at the surface of the bone, being thinner, has a somewhat bluish appearance, which is owing to its semi-transparency. The edges of the old cartilage are free, and extend over the very thin contour of the new cartilage.

In the joints of old persons affected with various other alterations, the diarthrodial cartilages are sometimes found converted into villous fibres, free and floating. When laid bare in amputation at the joints, if the wound unites by first intention, the cartilage and its synovial membrane do not unite, but remain free behind tho cicatrix. If the wound remains open, if it inflames and suppurates, the cartilage is seen at the end of some days to soften, and afterwards gradually to disappear from the circumference to the centre, in proportion as the granulations extend to the surface of the bone, and even before they reach it. Inflammation of the diarthrodial cartilages is in general of rare occurrence; and, when it takes place, commonly terminates by ulceration or absorption. This ulceration of the diarthrodial cartilages is most commonly consequent to inflammation of the synovial membrane or bone, sometimes to that of the cartilage itself, but it also sometimes seems not to be preceded by any inflammation. Sometimes, before ulcerating, the cartilage softens and assumes a fibrous appearance. This ulceration most commonly takes place in young subjects, or before middle age. It is accompanied by a pain, which is at first slight, but which gradually increases in intensity. When the ulceration stops and heals, there takes place a reproduction of cartilage, of which we have already spoken, or a bony production of the nature of ivory or enamel, or, lastly, a union of the surfaces by anchylosis. In the case of true anchylosis, the cartilages are always absorbed.

§ 557. The cartilages of the synarthrodial articulations, are extremely thin laminæ, placed between the bones which are articulated in an immoveable manner, and holding firmly on

each side to these bones by a kind of suture. Their edges, in the interval between the bones, are intimately attached to external and internal periosteum, which passes from the one to the other bone. Thus they greatly contribute to the solidity of these articulations. These cartilages, in the sutures of the skull, are thinner at the interior, than at the exterior of the wall, which in part accounts for the quicker disappearance of the sutures at the interior than at the exterior of the skull. With respect to the frequency of their ossification, they are intermediate between the temporary and the permanent cartilages.

ARTICLE II.

OF THE COSTAL, LARYNGEAL, AND OTHER CARTILAGES.

§ 558. The costal cartilages* are the longest and thickest cartilages of the body. They constitute cartilaginous prolongations to the bony ribs. The first of them may also be considered as anterior or sternal cartilaginous ribs. The cartilages are all attached to the anterior extremities of the ribs, like the synarthrodial cartilages. The first is even continuous with the sternum at the other extremity. The next six are articulated with the sternum by diarthrosis. The three following are in the same manner articulated with those which precede them. The last two are immersed in the intermuscular cellular tissue.

§ 559. The texture of these cartilages is very obscure, and at first sight they appear homogeneous. However, by maceration prolonged for at least six months, the costal cartilages divide into oval laminæ or plates, separated from each other by circular or spiral lines; and united together by some oblique fibres which they send into each other. These laminæ are themselves divided into radiated fibrils, and the fibrils at length into minute bundles, which are at length reduced into mucous

* Héissant, *Sur la structure des cartilages des côtes de l'homme et du cheval*, *in* Mém. de l'acad. des sc., 1748.

substance. All these divisions or separations are first produced at the circumference of the cartilage. The centre is more homogeneous, and is the last part that divides. This separation may be accelerated by drying in the sun a costal cartilage that has been macerated for two or three months. Acids produce a similar effect.

§ 560. The costal cartilages are somewhat flexible and highly elastic. In inspiration, the motion impressed upon the ribs by the muscles, bends them and twists them upon themselves; and when the muscular action ceases, they spontaneously resume their original direction, and are thus agents of expiration.

§ 561. After adult age, and in old age, the costal cartilages cease to be or to appear homogeneous. Their perichondrium becomes opaque, and there are produced, between it and the cartilage, and in its substance, bony plates, more or less numerous and broad, which sometimes end with forming a more or less complete bony sheath. This change almost always happens to the first, commencing at its sternal extremity. The other sterno-costal cartilages also experience it, but in a less degree. The asternal costal cartilages, or those of the false ribs, experience it still less, or not at all. At the same time the costal cartilages become yellowish, then reddish in their centre, which also presents more or less large and numerous bony points, which sometimes at length occupy the whole cartilage. This latter phenomenon shows itself more frequently and sooner in the asternal cartilages than in the others.

These changes in the cartilages are commonly the effect of age. They commence towards the middle of life, and go on continually increasing. Persons of a hundred and thirty and a hundred and fifty years, however, have been seen to have costal cartilages in their natural state.

When the cartilages begin to undergo this change, desiccation causes them to break across in the centre, which has become areolar, and not at the surface, which has, on the contrary, become denser.

They frequently ossify, and at an early age, in persons affected with phthisis.

§ 562. The costal cartilages, when denuded, do not produce granulations, but are covered by those of the neighbouring parts. When broken, they do not unite by a cartilaginous substance, but a cellular lamina is produced between them, and the broken place is enveloped with a bony ring furnished by the perichondrium, and which is more or less regular, according as the fragments have remained more or less exactly in opposition. I have sometimes seen in man, and repeatedly in the horse, the fractures of ossified asternal cartilages, united by a bony callus.

The costal cartilages are subject to some vices of original conformation, and are even liable to be wanting in whole or in part. In the latter case, it is always the extremity next to the rib that exists. When the thorax is deformed, when it is contracted, as sometimes happens after the cure of pleurisy, the cartilages of the affected side bend and become deformed.

§ 563. The nasal cartilage, that of the auditory canal, and that of the Eustachian tube, are in a manner articulated with the bones. Those of the larynx, on the contrary, are only attached to the bones by ligaments, and are connected together by moveable articulations.

These cartilages have still a certain thickness. When their perichondrium is raised, their surface is found to be smooth and compact. Long continued maceration divides these cartilages into soft and short fibres or filaments. Decoction and mineral acids produce the same effects.

These cartilages are flexible and elastic. By their solidity they preserve the form and cavity of the organs which they contribute to form. Those of the larynx present the remarkable peculiarity of a very rapid growth at the period of puberty. These same cartilages sometimes ossify from the adult age, at least in part. Chronic inflammation of the mucous membrane of the larynx, and its ulceration, greatly hasten this ossification, which, in fact, always takes place in phthisis laryngea, and is of frequent occurrence in phthisis pulmonalis.

When the thyroid and cricoid cartilages are divided, they unite by bony laminæ of the perichondrium, which are thicker at the exterior than at the interior of the larynx.

ARTICLE III.

OF THE MEMBRANIFORM CARTILAGES.

§ 564. The membraniform cartilages are those which Bichat has placed in his fibro-cartilaginous system. They are very thin, and possessed of great flexibility.

They are the palpebral cartilages or tarsi, the cartilage of the ear, those of the nostrils, the cartilage of the epiglottis, the median cartilage of the tongue, and the cartilages of the trachea and bronchi.

These very thin cartilages are furnished with a perichondrium, which is very thick and very strong compared with themselves, and sends into their substance fibrous and cellular prolongations, some of which even pass entirely through them. Their surface also is very uneven and porous. Maceration continued for two or three months softens them, and reduces them to the state of distinct fibrils at first, and finally into cellular or mucous substance.

They are very flexible, perfectly elastic, and much less brittle and more tenacious that the other cartilages. Like the preceding, they concur in forming organs or canals, of which they preserve the form and caliber. They are rarely ossified, and only at a very advanced period of life. The rings of the trachea alone present a more or less extended ossification in the adult. In cases of phthisis, however, the cartilaginous arches of the bronchi have been found ossified. In gouty persons also, and after inflammation of the ear, the cartilage of that part has been seen to become bony. In the case of goitre, and even without this cause of pressure, the cartilaginous rings of the trachea are sometimes found compressed from one side to the other, and their middle part bent at an angle. The same change of form is also observed in the bronchi.

CHAPTER VIII.

OF THE OSSEOUS SYSTEM.

§ 565. The osseous system,* or the skeleton, Σχελτεον, results from the union of the bones, which are the hardest and driest parts of the body.

§ 566. It is of all the systems that which shows itself last in the animal series; it appears along with the nervous centre (the spinal marrow and brain) to which it serves as an envelope.

§ 567. The same sense has not always been attached to the words bone and skeleton. In the writings of Hippocrates and Aristotle is found the source of the two principal ideas attached to these words, and which are still a subject of controversy among zootomists.

The author of the Treatise on the Nature of the Bones attributes to them the uses of determining the form, the straightness, and the direction of the body. This idea has prevailed, and it is still generally admitted, that the principal functions of the osseous system are to determine the form of the body, and to facilitate its motions. Agreeably to this definition,

* The best works on osteology are the following:—A. Monro, Anatomy of the Bones and Nerves. Edin. 1726, 8vo.—W. Cheselden, *Osteographia*, &c. Lond. 1733. fol.—B. S. Albinus, *de Ossibus corp. hum.* Lugd. Bat. 1726, 8vo.—Id. *de Sceleto hum.* ibid. 1762. 4to.—Id. *Tab. sceleti et muscul.* ibid. 1747. fol. max.—Id. *Tab. ossium.* ibid. 1753. fol. max.—Boehmer. *Institutiones osteologicæ.* Halæ-Magd. 1751.—Tarin. *Osteographie.* Paris, 1753.—Bertin. *Traité d'osteologie.* Paris, 1754. Ed. Sandifort. *Descriptio ossium hominis.* Lugd. Bat. 1785.—Loschge. *Die Knochen*, &c. *Abbildungen und kurzen Beschr.* Erlang. 1804. fol. Blumenbach. *Geschichte und Beschreibung der Knochen.* Gotting. 1807.

the hard parts of the other articulated animals, and especially those of the insecta and crustacea, ought to have been assimilated to the bones, for it is in the latter that voluntary motion and the preservation of the form of the body are carried to the highest pitch. Willis, in speaking of the crab, uses the following words:—*Quo ad membra et partes motrices, non ossa teguntur carnibus, sed carnes ossibus.*

Aristotle, however, who already considered the spine as the origin, or centre, from which the bones are derived, had given the first intimation respecting the distinction which has in these latter times been made between the bones and the other hard parts of animals. According to this idea, the skeleton, or osseous system of the vertebrate animals is, in fact, first, and principally seen to consist of a longitudinal column, which furnishes superiorly, or posteriorly, an envelope to the spinal marrow and brain, and anteriorly, or inferiorly, another envelope to the organs of nutrition, and especially to the central parts of the vascular system. Other less constant appendages are subservient to motion through their articulations. All the parts of the system, besides, may furnish attachment to muscles.

The question, therefore, is, whether all the hard and dry parts of the body of animals, those which determine its form and facilitate its motions, are to be called bones and skeleton; or if these names are to be restricted to the hard parts, peculiar to the vertebrate animals, which form a central and median column in the body, with a cavity for the nervous trunk, and another cavity for the heart and aorta, and frequently lateral appendages for motion.

According to M. Geoffroi Saint-Hilaire, one of the naturalists who has engaged most deeply in the study of this point of zootomy, and who has treated it with his original talent, there is no doubt on the subject, and all the difference between the skeleton of an articulate and a vertebrate animal, between the rachis of a crustaceous animal or an insect, and that of an osseous animal, depends upon the absence of a spinal marrow in the former, and its presence in the latter; a difference which renders necessary a rachis with two canals in the vertebrate

animals, and one with a single canal in the crustaceous. According to this last idea, if I understand it well, an insect or a crustaceous animal could be correctly compared to a monstrous vertebrate animal deprived of brain and spinal marrow.

§ 568. Be this as it may, however, with respect to this difference of opinion, altogether foreign to the anatomy of man, there are three things to be considered in the osseous system; the bones themselves, their articulations, and the skeleton which results from their union.

SECTION I.

OF THE BONES.

§ 569. The Bones, *Ossa*, Οστεα, are the hardest parts of the human body, those which by their union form the skeleton.

§ 570. Each of the bones, and many parts of bones, have received particular names. These names ought to be so much the more precise and appropriate, that the names of many other parts of the body are formed from them.

The name of several bones is an adjective taken substantively with a common termination: for example, the frontal, occipital, parietal, &c.* M. Dumeril† has proposed, as a means of giving precision and accuracy to the language of anatomy, to give the same termination to all the names of bones, and to them only.

§ 571. The number of the bones is very great, but differently determined, according as we take the subject at a particular age, or different subjects at different ages; and this is what has most commonly been done. If, for example, it be wished to determine the number strictly, taking the adult subject, the sphenoid bone then occurs united to the occipital, and often to the ethmoid; but the sternum is still divided into three parts,

* This mode of expression is correct in French, but it is incorrect in English, and we are obliged to say, the frontal bone, the occipital bone, &c.

TRANS.

† *Projet d'une nomenclature anatomique*, Magasin Encyclopedique, t. ii. Paris, 1795.

and the hyoid bone is still composed of at least three distinct pieces.

The following is an enumeration of the bones which most anatomists agree in describing as distinct.

Twenty-four moveable vertebræ.

Five pelvic vertebræ, united to form the sacrum or pelvic bone.

Three or four caudal vertebræ, united to form the coccyx.

Twelve ribs on each side; a single sternum, formed of three distinct pieces in the adult.

An occipital bone, a sphenoid bone, an ethmoid bone, a frontal bone, two parietal bones, two temporal bones, each containing three ossicula tympani; a vomer, two upper maxillar bones, two palate bones, two zygomatic bones, two nasal bones, two lachrymal bones or ossa unguis, two inferior turbinated bones, an inferior maxillar bone.

A hyoid bone, composed, even in the adult, of three or five distinct pieces.

The bones, which remain to be enumerated, are all paired, or double, and are those of the limbs or extremities; viz.

The scapula, the clavicle, the humerus, the radius, the ulna, the eight bones of the carpus, the five of the metacarpus, the two phalanges of the thumb, the three phalanges of each of the other fingers, and five sesamoid bones.

The coxal bone, the femur, the tibia and patella, the fibula, the seven bones of the tarsus, the five bones of the metatarsus, the two bones of the great toe, the three bones of each of the other toes, and three sesamoid bones.

§ 572. The situation of the bones is always internal, or deep. Whether they form cavities for the nervous and vascular centres, or form the limbs, they are all covered by the muscles and the teguments; none of them being external.

§ 573. The bones vary greatly as to size, some being a fourth, fifth, or sixth of the length of the body, while others have scarcely a diameter of a few lines. With reference to size, the bones are divided into large, middle sized, small, and very small, or ossicula.

§ 574. The form of the bones is symmetrical; Some are

single and median, the others lateral and in pairs. In the former, the lateral halves are similar to each other; in the latter, each of the bones is similar to that of the opposite side of the body. There are in this respect only very slight irregularities.

The single bones, which are all situated on the median line, are the vertebræ, as well those which are moveable, as those of the sacrum and coccyx; the sternum, the occipital bone, the sphenoid, the ethmoid, the frontal bone, the vomer, the inferior maxillar bone, and the hyoid bone.

All the rest are paired or double, and are situated on the sides of the median line, at a greater or less distance from that line.

The bones are divided according to their form, and according to the proportion which their three geometrical dimensions bear to each other, into long, broad, short, and mixed. In the first, one of the dimensions greatly preponderates over the other two; in the broad bones, the length and breadth greatly exceed the thickness; in the short bones, the three dimensions are nearly equal; and the mixed bones participate, in different parts of their extent, of the characters of the bones of two kinds.

§ 575. The long bones, *ossa longa seu cylindrica*, are situated in the limbs, where they constitute broken or jointed columns. The number of these bones, in each fraction of the limbs, increases, and their length diminishes, as we recede from the trunk. Each long bone is divided into a body or middle part, and two extremities. The body or diaphysis, is cylindrical in some of them, and in others has the form of a triangular prism. It is generally a little bent and twisted. The extremities are enlarged.

The broad bones, *ossa lata, sue plana*, are situated in the trunk, where they constitute walls of open cavities, and more or less solid. These bones, which are flattened in two opposite directions, are curved, and some of them twisted. They are semi-circular, quadrilateral, or polygonal. Their edges are generally a little thickened.

The short or thick bones, *ossa crassa*, are situated in the vertebral column, in the hand, and in the foot, where, by their assemblage and multiplicity, they form solid and moveable

parts. They are globular, tetrahedral, cuneiform, cuboidal, or polyhedral.

The mixed bones, *ossa mixta,* are those which partake of the character of several kinds. They are numerous: the occipital bone, the sphenoid bone, the temporal bone, the coxal bone, the sternum. The ribs participate of the character of the broad and short bones. The long bones themselves resemble the thick bones at their extremities.

§ 576. There are distinguished in the external conformation of the bones, parts, or regions of their extent.

In the single bones there are, in general, either an azygous and median parts, and lateral parts, as the body and processes of the sphenoid bone, the body and the apophysal masses of the vertebræ, &c. or lateral parts only, united in the median line, as the two halves of the frontal bone, &c.

Many bones divide into parts or regions, determined by their mode of formation or development. Thus, the hip bone is divided into ilium, ischium, and pubis, the sphenoid bone, the ethmoid bone, the temporal bone, &c. into several regions equally distinct by the mode of their development.

In other bones, the division into regions results solely from the situation and uses of the parts. Thus, the outer surface of the frontal bone is divided into an orbitar and nasal region, a frontal region, &c.

There are also admitted in the bones geometrical regions or parts of their extent. Thus, there are distinguished and described in the long bones, a body or central part and extremities; in the broad bones, faces, edges, and angles, &c. but these terms are not strictly applied, for planes and angles are very rare and imperfect in the organization.

§ 577. The bones present at their surface eminences and depressions which are greatly diversified.

The eminences of the bones are distinguished into epiphyses and apophyses. The epiphyses have relation to the development, and will be described when we speak of it.

The apophyses are bony eminences, continuous with the substance of the bones. They are extremely numerous and highly diversified. Few objects in anatomy have, according-

ly, been more differently arranged. They are distinguished into articular and non-articular. The former will be described as we proceed.

The non-articular apophyses are somewhat rough. Their size and their very diversified form allow them to be divided into three kinds. Some, which are long and projecting like a branch or a bony ramification, bear the name of branches, processes, and apophyses, properly so called.

Others, which are shorter and thicker, bear the name of protuberances, tuberosities, and tubercles.

The others, which are elongated, narrow, and little protruding, bear the name of crests, ridges, and lines.

The synonymy of these different kinds of eminences is very complicated and difficult. They are generally designated each by names derived from trivial and rather loose comparisons, sometimes also by names derived from their situation, their size, their direction, and their uses.

Their general use is that of affording insertion to ligaments and tendons.

§ 578. The external cavities of the bones are, like their eminences, distinguished into articular and non-articular. It is of the latter only that we have to speak here.

Of these cavities, some traverse, and others do not traverse, the substance of the bone. Of the latter, some have a widened entrance, sloped in all directions. These are fossæ, fossettes, and digital impressions. The others have the bottom wide, and the entrance narrow, and are lined by the mucous membrane, and filled with air. These are sinuses, and when they are divided into several cavities, cells, or cellules. Others are elongated, narrow, more or less deep. These are called furrows, channels, meatuses, and grooves. The cavities of this latter kind, when they exist on the edge of bones, bear the name of notches or incisions.

Of the cavities which traverse the bones from side to side, some follow the shortest course, through a thin bone, and are holes, slits, or fissures, others follow a longer and variously contorted course, and are canals, conduits, &c.

Sometimes several bones unite to form a cavity, as the skull

and vertebral canal, the pelvis, the thorax, the nasal fossæ, the orbits, &c.; or even to form a hole or a conduit, as the spheno-palatine hole, the foramen lacerum posterius, &c. the orbital, palatal, and other conduits.

Of these simple or compound cavities, some lodge organs, others furnish insertions, and others serve to transmit, or afford a passage to certain parts.

In certain places of the bones, there occur a multitude of small eminences and depressions, very close to each other. This constitutes impressions or inequalities which serve for insertions.

§ 579. The bones have internal and closed cavities, which are called medullary cavities, because they contain the medulla, or fat of the bones.(169)

The long bones have a large cylindrical medullary cavity, which occupies their body, or middle part, and which, at its extremities, communicates with the areolæ of the spongy substance. This cavity lodges the medullary system, and renders the bone lighter under the same volume, and stronger with the same weight.

The extremities of the long bones, the short bones, the broad bones, and especially their thick edges, contain areolar cavities, which also lodge marrow.

Lastly, there are some also whose substance is compact, containing only microscopic medullary cavities.

§ 580. The bones have also vascular canals for the vessels of the marrow, and for those of their proper substance.

Each long bone has at least one canal of this kind, which passes obliquely through the walls of the medullary cavity, penetrates into it from above downwards in the humerus, the tibia and the fibula, and from below upwards in the femur, the radius and the ulna. This canal gives passage to the vessels and nerves of the medullary membranes.

The extremities of the same bone, the short and thick bones, and the thick edges of the broad bones, are furnished with a very great number of wide canals, which in like manner afford passage to vessels, and especially to large veins.

Lastly, the whole surface of the bone is riddled with a mul-

titude of small holes or orifices of canals into which very small vessels penetrate.

§ 581. The density of the osseous tissue is very great, but it is not the same in all parts of the same bone. With reference to this circumstance, the substance of the bone is distinguished into compact and spongy or areolar. The first is cortical, or situated at the exterior of the bones. The other is internal.

The compact substance is that whose density is such that no interstices are perceived in it by the naked eye, although it is perforated with many medullary and vascular canals visible to the microscope. In the long bones, these canals are longitudinal. They have frequent lateral communications with the great medullary canal, and the outer surface of the bone. They are smaller towards that surface than towards the other. Their mean diameter is the twentieth of a line.

The areolar, or spongy substance, is that which forms small cavities, distinctly visible to the naked eye. This substance presents several varieties, of which the principal are the following:—It consists of filaments more or less fine, and of laminæ of a like tenuity, in the extremities of the long bones, and in the substance of the short bones; of reticulated filaments and laminæ at the internal surface of the medullary canal of the long bones; and of strong laminæ, forming narrow areolæ in the broad and thin bones, especially in those of the skull.

The two substances, or varieties of the more or less dense tissue of the bones, are arranged in a particular manner in each kind of bone.

In the long bones, the body is formed of compact substance, and the inner surface of the canal is bristled with some reticulated filaments and laminæ. Towards the extremities, the compact substance greatly diminishes in thickness, the areolar or spongy substance becomes more and more abundant and fine, the great canal ends by becoming continuous with the spongy substance, with which the whole extremity of the bone is filled.

In the broad bones, the two surfaces are formed of compact substance. Wherever the bone is thin, these two laminæ touch

each other. On the contrary, where it is thick, they are separated by a layer of spongy substance, proportionate to the thickness of the bone. In the bones of the skull, the inner table, which is still denser, but thinner and more fragile than the outer table, bears the name of vitreous lamina, and the spongy substance, that of diploe.

The short bones are formed of spongy substance, surrounded by a layer of compact substance.

Lastly, the mixed bones, in the disposition of the two substances, participate in the nature of the kinds of bones to which they belong.

The two varieties of tissue, or the two substances of which we have been speaking, are, in reality, one and the same tissue, one and the same substance, differently disposed, rarefied in one part and condensed in the other. A piece of compact substance is exactly the same thing as a lamina or a filament of spongy substance. A given longitudinal section of a long bone, contains, to appearance, the same quantity of osseous tissue as another equal longitudinal section of the same bone; but in the one, the substance, or tissue, is condensed, and leaves a large canal in its centre, while in the other, the tissue is rarefied, and the canal replaced by a multitude of spongy areolæ. These two substances can be transformed into each other. The essential difference which they present is, so to speak, foreign to them; it depends upon the presence and the penetration of the medullary tissue, and upon its numerous vessels in the very substance of the spongy bone, and upon its contact on one of the faces only of the compact bone.

§ 582. The texture of the bones* is one of the points of

* Malpighi. *de Ossium structurâ, in op. posth.*—D. Gagliardi, *Anatome ossium novis inventis illustrata.* Romæ, 1689.—Cl. Havers, *Osteologia nova, &c.* Lond. 1691.—*Description exacte des os, comprise en trois traités, par* J. J. Courtial, J. L. Petit, et Lémery.—Delasône, *Mém. sur l'organisation des os,* in *Mém. de l'Acad. Royale des Sciences.* Paris, 1751.—J. F. Reichel, *de Ossium ortu atque structurâ.* Lips. 1760.—B. S. Albinus, *de Constructione ossium,* in *Annot. Acad.* Lib. vii. cap. 17.—Perenoti, *Mém. sur la construction et sur l'accrossement des os. Mem. de Turin,* t. ii. 1784.—A. Scarpa, *de Penitiori ossium structurâ commentarius.* Lips. 1795, and Paris, 1804.—

anatomy that has given rise to the greatest number of writings and investigations. Malpighi, the first author who deserves mention, considers the tissue of the bones as resulting from laminæ, fibres, and filaments, with an intermediate bony juice. It is, according to him, like a sponge filled with wax. Gagliardi admits laminæ or bracteæ, and bony threads of different forms, which resemble them. Havers is pretty much of Malpighi's opinion, and admits laminæ formed of fibres, and connected by the bony juice. Lasône describes laminæ formed of ossified fibres, connected with each other by oblique filaments. Reichel, having examined portions of bones softened in a mineral acid, saw that they might be divided into laminæ, and then into fibres, forming a porous and tubular whole, which is continuous with the spongy substance. Scarpa concludes, from the examination of healthy and diseased bones, of bones entire and deprived of earthy substances, and of bones before and after their entire envelopment, that the osseous tissue, even the compact substance, is a cellular and reticulated tissue, entirely similar to the spongy substance. Medici has observed, and the circumstance has long been known to those who extract gelatine from bones, that the compact substance of the long bones, deprived of earthy salts by the action of a weak acid, divides into several laminæ or layers, adhering to each other by fibres.

§ 583. To examine the texture of the bony tissue, it being extremely hard, one is obliged to have recourse to chemical processes which, in decomposing the bone, must have some action upon the part which remains subjected to examination. Be this as it may, if a bone be immersed for some days in a vegetable acid, or in a mineral acid diluted with water, the saline substance which enters in large proportion into the

V. Malacarne, *Auctuarium obs. et icon. ad osteol. et osteopath. Ludwigii et Scarpæ*, Patav. 1801.—Howship, Microscop. Observ. on the Structure of Bone, in Medico-Chir. Trans. vol. vii. Lond. 1816.—M. Troja, *Osservazioni es edperimenti sulle ossa*, Napoli, 1814.—Medici, *Esperienze intorno alla tissitura organica delle ossa, in opuscoli scientifici*, t. ii. Bologna, 1818.—*Considerazioni intorno alla tess. org. delle ossa, scritte da M. Medici, &c. in riposta alle oppos. fatt. dal. S. D. C. Speranza, e dal S. Cav. A. Scarpa*, Bologna, 1819.

bone, is removed from it, and the bone, retaining its form and size, but having lost a part of its weight, equal to that of the earthy matter abstracted, has become flexible and tenacious like the cartilaginiform fibrous tissue. In this state it is reducible to glue or gelatin by decoction. In this state also, if it be softened by maceration in water, the compact substance, which presented no apparent texture, divides into laminæ, connected together by fibres. The laminæ themselves, somewhat later, or with more difficulty, divide into fibres, which, by a more prolonged maceration, swell, and become areolar and soft, like the cellular or mucous tissue.

A long bone, examined by this method, divides at its middle part into several layers, of which the outermost envelops the whole bone, and of which the next, becoming thinner towards the extremities, are continuous with the spongy substance with which they are filled. The broad bones are formed of two laminæ only, and the short bones of a single lamina which envelops them; this latter, like the others, presenting at its internal surface filamentous and laminar prolongations which constitute the spongy substance.

The bony fibre differs therefore especially from the other animal fibres in the great quantity of earthy substance which it contains.

In fact, if in place of removing this earthy substance and examining the organic residuum of which we have just spoken, this latter be destroyed, by submitting a bone to the action of fire, there remains a white substance, preserving the volume, form, and a great part of the weight of the bone. This hard, but very fragile substance, is an earthy salt, which forms part of the bony tissue. The other tissues leave, after combustion, a similar residuum or ashes, but in much less proportion, and not preserving, like those of the bones, the form and a part of the solidity of the whole.

§ 584. The bony fibre is therefore a fibre very similar to the cellular one, but differing from it in the very great quantity of earthy substance which enters into its composition. Various ideas have been formed as to the intimate nature of this fibre. The opinion most generally admitted consists in

viewing the tissue of the bones as an areolar organic tissue like the others, but containing earthy substance in extremely narrow cavities, much in the same manner as water is interposed in the tissue of a moist sponge. Others consider the bone as an intimate mixture or a combination of gelatine and phosphate of lime. Mascagni regards it as formed of absorbent vessels filled with phosphate of lime. These hypotheses however, do not rest upon any fact, or rather are in contradiction to facts. At the same time it is not known in what exact proportion the earthy substance exists to the organic substance of the bones.

§ 585. Some tissues belong essentially to the organization of the bones: these are the periosteum, the marrow, and the vessels.

The periosteum is a very vascular fibrous membrane which envelops the bone, as has already been seen (522.)

The medullary membrane is a very vascular cellular membrane, which contains the marrow, and serves as an internal periosteum to the bones (169—178.)

The blood-vessels of the bones, which are pretty numerous, and of different volume, are distinguished into those which first ramify in the outer periosteum, and then penetrate into the small nutritious foramina of the compact substance; those which penetrate, without ramifying, into the medullary canal, where they are distributed to the membrane of that name, and then penetrate through the inner surface into the compact substance, where they communicate with the preceding; and, lastly, into those which penetrate through the large and numerous foramina of the short bones and spongy parts of the long and broad bones, to be distributed in the spongy substance, and communicate there, in the long bones, with the vessels of the two first orders. Some anatomists have given the names of nutritious vessels of the first order to those of the medullary canal of the long bones; nutritious vessels of the second order, to those of the spongy part; and of the third order, to those which pass from the outer periosteum into the compact substance. In general, each of the nutritious canals contains an artery and a vein. Those of the second order contain very

large veins, with very thin walls, which appear to consist only of the inner membrane. These veins appear to have great communication with the medullary cavities of the spongy substance.

Lymphatic vessels are seen at the surface of the large bones only.

No other nerves are seen in the bones than those which accompany the vessels of the medullary membrane.

§ 586. The great hardness of the bones depends upon their chemical composition. Of all the organized parts, in fact, as has been seen, they contain the greatest proportion of earthy substance. It must have been known all along that the bones are combustible, and that they leave an earthy residuum. It has also long been known that the bones furnish gelatine or glue by decoction. It was Scheele who announced that the earthy part of the bones is phosphate of lime. A hundred parts of fresh bone are reduced to about sixty by calcination.

According to the analysis of M. Berzelius, human bones, deprived of water and fat, have the following composition: animal matter reducible to gelatine by decoction, 32.17; insoluble animal substance, 1.13; phosphate of lime, 51.4; carbonate of lime, 11.30; fluate of lime, 2.0; phosphate of magnesia, 1.16; soda and muriate of soda, 1.20.

Fourcroy and M. Vauquelin, in their first trials, did not find phosphate of magnesia in human bones. According to M. Hildebrandt, there is none of that substance in them. According to Dr. Hatchett, there is sulphate of lime in them, which, according to M. Berzelius, is a product of calcination. Lastly, Fourcroy and Vauquelin admit, moreover, in the bones, iron, magnesia, silica, alumina and phosphate of ammonia, but no fluate.

Besides the differences of composition dependent upon age, individual constitution, and morbid affections, circumstances which make the proportion of the animal substance and the earthy substance vary, all the bones have not exactly the same composition in the same individual. Thus the bones of the skull generally contain a little more of earthy substance than

the others. The petrous portion of the temporal bone is of all the parts that which contains most.*

§ 587. The bones are of a yellowish white colour and opaque, but it is especially by their hardness, their little flexibility, and their resistance to rupture that they are remarkable, and it is by these properties that they perform their part in the organism. However little flexibility and compressibility they possess, they are elastic.

They also possess a slow but real extensibility and power of contraction. Thus the maxillar sinus, the nasal fossæ, the orbit, &c. are gradually enlarged by the development of tumours in their interior. These cavities also return to their previous state when they are freed of these causes of extension. The alveoli contract and become effaced after the loss of the teeth, &c.

They possess no other kind of contraction. Sensibility exists in them only in the morbid state. Their power of formation is very remarkable in these two respects, that all the phenomena which belong to it, as their first formation, separation, alterations of texture, &c. take place in a very slow manner, while the faculties of reproduction and accidental production are greater in them than in any other tissue.

§ 588. The formation of the bones, ossification, or osteogenesis† is a phenomenon which has much occupied the attention of observers, and which is, in fact, highly worthy of it.

* John Davy, in Monro's Outlines of the Anatomy of the Human Body. Edinb. 1813.

† H. Eysson. *de Ossibus infantis, cui tractatui annexus est* V. Coiter, *Ossium infantis historia*, 12mo. Groning. 1659.—Th. Kerkring. *Osteogenia fœtus.* Lugd. Bat. 1717.—R. Nesbitt. The Human Osteogeny. Lond. 1736.—J. Baster. *De Osteogenia.* Lugd. Bat. 1731.—A. Vater et Ulmann. *Osteogenia.* Viteb. 1733.—Albinus. *Ann. Acad.* lib. vi. vii.—Id. *Icones Ossium Fœtus Humani. accedit Osteogeniæ brevis historia.* Lugd. Bat. 1737. —Duhamel. *Mém. de l'Acad. Roy. des Sc.* 1739, 41, 43–46.—Haller, *Experimenta de Ossium formatione in op. min.* ii.—Hérissant, *Mém. de l'Acad. Roy. des Sc.* 1768.—C. F. Senff. *Nonnulla de incremento ossium embryonum in primis graviditatis mensibus.* Halæ, 1801.—J. Fr. Meckel. *Deutsches Archiv. fur die Physiolog.* b. i. ii. 4.—J. Howship. Exper. and Observ.

The bones experience in their development, transformations so much the more remarkable, that the different states through which they pass correspond to similar, but permanent states, which are observed in animals.

After being fluid, like all the other parts, they become, first, soft, mucous, or gelatiniform; secondly, cartilaginous, and some of them fibrous and cartilaginous; thirdly, osseous.

The bones are mucous, transparent, and colourless, at a period very close upon conception. They then grow by vegetation, and form a continuous whole which is subsequently divided.

The cartilaginous bones, or temporary cartilages, do not make their appearance until the end of the second month after conception. This state can be perceived only in the bones or the parts of bones which harden somewhat late, for it is doubtful whether those which ossify at a very early period pass through the cartilaginous state, a state which appears rather destined to perform the functions of bones previously than to be a period of ossification.

The osseous state commences successively in the different bones, from about a month after conception, in those which ossify soonest, to about ten or twelve years after birth, in those which are longest in becoming ossified. There are even certain accessory bony points which do not begin to form until towards the fifteenth or eighteenth year.

§ 589. The order in which the bones begin to appear and to harden, has seemed capable of being reduced to rules.

Thus the clavicle and maxillæ being very early in their development, the sternum, the pelvis, and the limbs being later, it has been said that the earliness is in relation to the importance in the animal kingdom, or rather in the class of vertebrate animals, where we in fact see, from the class of fishes upwards, the clavicles and maxillæ developed at a very early period,

on the Formation of Bone, in Med. Chir. Trans. vol. vi. Lond. 1815.—A. Béclard. *Mém. sur l'Ostéose, in Nouveau Journ. de Med.* vol. iv. 1819.—Serres. *Des Lois de l'osteogenie, Analyse des trav. de l'Acad. Roy. des Sc.* 1819.

while the sternum, pelvis, and limbs are so in but a very small degree.

It has also been established as a general proposition, that the bones which are first formed are those which are near the sanguineous and nervous centres, the ribs and vertebræ being in fact developed at a very early period.

It has also been said, that the long bones appear first, then the broad bones, afterwards the short bones; the clavicle, femur, and tibia appearing from the commencement, and the bones of the tarsus and carpus at a much later period.

Lastly, It has been thought that the large bones ossify first and the others successively.

There are many exceptions to these rules.

§ 590. Ossification commences at the end of the first month in the clavicle, and successively in the inferior maxillar bone, the femur, the tibia, the humerus, the upper maxillary bone, and the bones of the fore-arm, in which it commences about the thirty-fifth day. It commences about the fortieth day in the fibula, the scapula, and the palatal bones, and the following days in the proral portion of the occipital bone, in the frontal bone, the arches of the first vertebræ, the ribs, the great wing of the sphenoid bone, the zygomatic process, the phalanges of the fingers, the bodies of the middle vertebræ, the nasal and zygomatic bones, the ilium, the metacarpal bones, the extreme phalanges of the fingers and toes, the condyles of the occipital bone, and then in its basilar portion, in the squamous portion of the temporal bone, in the parietal bone, and in the vomer, in all which bones it commences about the middle of the seventh week. In the course of the same week it also commences in the orbitar wing of the sphenoid bone, and lastly in the matatarsal bones, the phalanges of the toes and the second phalanges of the fingers. In the ten following days it commences in the body of the sphenoid bone, in those of the first sacral vertebræ, and in the ring of the tympanum. About the middle of the third month it shows itself in the costiform appendage of the seventh vertebra, before the end of the third month, in the labyrinth, and towards the end of the same month, in the ischium and inner pterygoid process;

towards the middle of the fourth month, in the ossicula tympani; at mid term, in the pubis, the calcaneum, the second phalanges of the toes, the lateral masses of the ethmoid bone and the turbinated bones of the nose; a little later in the first pieces of the sternum; towards the sixth month, in the body and odontoid process of the second vertebra, and in the lateral and anterior masses of the first pelvic or sacral vertebra; a little later still, in the astragalus; towards the seventh month, in the sphenoidal turbinated bone; at a later period, in the median ridge of the ethmoid bone; towards the period of birth, in the os cuboides, the first vertebra of the coccyx and the anterior arch of the atlas; a year after, in the coracoid bone, the os magnum and os unciforme of the carpus, and in the first cuneiform bone; about the third year, in the patella and pyramidal bone; about the fourth year, in the third and second cuneiform bones; about the fifth year, in the os scaphoides of the tarsus, the trapezium and os lunare; towards the eighth year, in the scaphoid bone of the carpus; a year after, in the os trapezoides, and lastly, about the twelfth year, in the os pisiforme.

§ 591. Ossification does not everywhere result from the transformation of cartilage into bone. The diaphysis of the long bones and the centre of the broad bones, which are developed at a very early period, pass immediately from the mucous to the osseous state. The other parts of the system are at first cartilaginous, and it is in them that the successive phenomena of ossification may be best observed.

The cartilage, which for a longer or shorter period takes the place, and performs the functions of the bone of which it has the form and of which it gradually acquires the volume, is at first hollowed with irregular cavities, then with canals lined by vascular membranes filled with a mucilaginous or viscous fluid; it becomes opaque, its canals become red, and ossification commences towards its centre.

The first point of ossification, *punctum ossificationis*, always appears in the substance of the cartilage, and never at its surface. It is surrounded by red cartilage at the place which is in contact with it, opaque and full of canals at a little dis-

tance from it, and at a still greater distance homogeneous and without vessels, but only perforated with some canals of blood-vessels which tend towards the osseous centre. The osseous point continually increases by growth at its surface, and also by interstitial addition in its substance. The cartilage, successively perforated by cavities and canals lined by sheaths of blood-vessels, gradually diminishes in proportion as the bone increases, and at length disappears. The canals of the cartilages themselves, which are very wide at the commencement of ossification, become smaller and smaller, and at length disappear when it is completed. In the place of a cartilage more or less thick, but at first full or solid, without cavities and without distinct vessels, at a later period perforated with canals lined by vascular and secreting membranes, there is found a very vascular bone, full of areolar or spongy cavities, invested with membranes and filled with adipose marrow. The bone afterwards becomes less vascular as age advances.

§ 592. The cause of ossification, like that of organic formation in general, is unknown. From Hippocrates and Aristotle to Scarpa, Bichat, and Mascagni, a multitude of more or less ingenious hypotheses have been proposed on this obscure subject.*

It has been said, that the last divisions of the arteries ossify, or are filled up with bony matter, and that after being filled with bony matter, they burst, and allow it to escape around them. It has also been said, and with more probability, that they form, and allow to escape the ossifying matter, whether by exhalent extremities, or by lateral porosities. But what is this bony matter? Is it earthy substance? Where do the arteries pour forth this substance? Is it in the interstitial areolæ of a cartilage, as has commonly been said since the time of Herissant? or in absorbent vessels which are filled up, as Mascagni alleged? These are so many mere hypotheses. All that is known is this;—that the vascularity greatly increases before ossification, and that it always precedes that process; that the cartilage diminishes and disappears in proportion as

* See Sœmmering, *De Corporis. Hum. fabricâ*, T. 1. *De Ossibus.*

the bone forms and augments; and that the bone, which is highly vascular at the period of its formation, becomes afterwards less and less so. As to the state in which the bony substance is deposited, it is under the fluid form, and its successive hardening depends either upon the continual addition of a greater proportion of earthy substance, or upon the absorption of the vehicle which gave it its fluidity. Ossification does not depend upon the deposition of the earthy substance in an organic tissue, but upon the simultaneous formation of a tissue containing at once both the animal substance and the earthy substance.

The phenomena of ossification are different in the different kinds of bones.

§ 593. Ossification takes place at a very early period in the long bones, commencing in them from one to two months after conception, according to the bone. Before the commencement of ossification, no cartilages are observed in them. It is the same also with them at the commencement of ossification; there then being observed only a mucilaginous substance between the osseous cylinders. These osseous cylinders are at first thick and short, whence results that they may elongate greatly before growing thick. They correspond to the point at which the principal medullary artery is afterwards perceived. At the commencement of the third month, there are perceived cartilaginous extremities at the end of these elongated bony cylinders. Do these issue by vegetation from the interior of the canal? These cartilaginous extremities have the same conformation as the extremities are to have at a later period; they ossify, as has been said, in treating of ossification in general. Most of them only ossify at the centre, and then form epiphyses, which remain a greater or less time distinct at the ends of the bones. In some of them ossification goes on from the commencement, by the extension of the body of the bone, in the centre of their cartilaginous mass.

§ 594. The broad bones of the skull begin to ossify between the sixtieth and seventieth days. The pericranium and dura mater are then very vascular. There exists between these two membranes a mucous substance, which is itself very

vascular. The first bony points appear in the places which are most full of blood-vessels, under the form of isolated grains, afterwards disseminated and collected into net-works. They then form a lamina thin at the middle, and furnished with radiating bony fibres at the circumference. The surfaces of the bone are covered, and the intervals between the radiating fibres are filled up, by a reddish and very vascular mucilaginous substance. The pericranium and dura mater are still very red and vascular at that period.

§ 595. The short or thick bones ossify in the same manner as the extremities of the long bones. They are preceded in their formation by cartilages which have the form, and ultimately the volume of the bones which are to replace them. These cartilages are at first homogeneous and full, and afterwards present the successive changes already described: cavities, vascular membraneous canals, filled with viscous fluid, and bony points which extend from the centre to the circumference.

The patella and sesamoid bones are formed in a tissue which is at first fibrous, then cartilaginous, and in the same manner as the short bones.

The mixed bones, are intermediate in their formation, as they are in their external figure, and internal conformation, between the bones of the two different classes.

§ 596. Many bones are formed by several distinct points of ossification.

Several median bones, whether broad or thick, are formed by two lateral parts, which afterwards unite in the median line. Of this kind are the arches of the vertebræ, the frontal bone, the body of the sphenoid bone, the squamous portion of the occipital bone, the inferior maxillar bone, and the middle pieces of the sternum. But in several of the median bones also, ossification commences at the middle, and extends towards the sides, as in the body of the vertebræ, the basilar portion of the occipital bone, the crest of the ethmoid bone, the body of the hyoid bone, and the first and last bones of the sternum, whether the bone is formed of two lateral portions at an earlier period, at the period of its conversion into cartilage, for example, or whether it be originally single.

Many bones, broad as well as short, are formed of several principal or original points of ossification, which unite more or less quickly. Frequently these points correspond to distinct bones in other genera or classes of animals. Of this kind are the points of ossification of the vertebræ, the occipital bone, the sphenoid bone, the temporal bone, the maxillary bone, the sternum, the coxal bones, the sacrum, &c. There even occurs in the ruminating animals an example of the collateral union of two long bones to form the cannon bone.

§ 597. Lastly, a great number of bones, especially of long bones, and some broad and short bones, have accessory or secondary points of ossification, which are called epiphyses* on account of their being implanted upon the body of the bone, by means of a cartilage which lasts for a longer or shorter period. The large long bones of the thigh, arm, leg, and forearm, have at least one epiphysis at each extremity.

The clavicle, the metacarpal, metatarsal and phalangeal bones, have epiphyses at one extremity only.

Of the broad bones, the coxal bones, and the scapulæ, have marginal epiphyses analogous to these terminal epiphyses of the long bones. The ribs have epiphyses at their dorsal extremity, and at their tubercle.

Of the short bones, the vertebræ are almost the only ones that have epiphyses; they have them at the two faces of their body, and at the summit of all their processes which are not articular. Of the other short bones, the calcaneum is the only one that has an epiphysis. It is situated at its posterior extremity.

The epiphyses begin to form at very different periods, from about fifteen days before birth, to fifteen or eighteen years after, and remain for a longer or shorter time distinct before uniting with the body of the bone. The periods at which they unite are comprehended between the fifteenth and twenty-fifth year. Of all the epiphyses, the one which ossifies first, is that of the lower extremity of the femur, ossification commencing

* Platner. *De Ossium Epiphysibus*, 1736.—Ungebauer. *Epistola de Ossium trunci corp. hum. Epiphysibus Sero Osseis earundemque Genesi.* Lips. 1739.—Béclard, *loc. cit.*

in it previous to birth; and it is one of the latest in being united to the body of the bone. That of the upper extremity of the radius, which is one of the last to ossify, is perhaps, on the contrary, the one which is soonest in uniting.

§ 598. The growth of the bones takes place in an evident manner, by the successive addition of new bony substance around that which was first formed.

The growth in length occurs by the elongation of the body of the long bones at their extremities. For this purpose, the ends of the bony cylinder are covered with bony filaments or villosities immersed in the not yet ossified extremity, hollow and vascular, which continually elongate, becoming more and more slender as the vessels ramify more, and as the ossification slackens. At the same time, the cartilaginous extremities, commencing at the centre, are gradually transformed into bones which constitute epiphyses.

The growth in breadth takes place, in the flat bones, in the same manner, whether by the successive addition of bony substance in the edge of the bone, as in the bones of the skull, or by the osseous formation, under a marginal epiphysis, which covers its edge, as in the scapula and coxal bone.

The growth in thickness occurs in all the bones in the same manner. The periosteum, which until this period is very vascular, secretes and deposits between its fibres, at the surface of the bone, osseous substance, at first mucous, then hard, which being thus successively added to the surface, increases the thickness of the bone.

§ 599. The growth of the prominences of bones takes place in the same manner as that of the long bones furnished with epiphyses, that is to say, between the body of the bone and the base of the eminence; as in the trochanters, &c. In others, it is at the surface itself that the growth occurs, precisely in the same manner as the growth in thickness of the bones. Most of the eminences grow in this way. As to the hollowing of the external cavities which are not articular, it is in many places determined by pressures, which without really depressing the bone, nevertheless produce a depression of it,

by rendering its nutrition less active than in the surrounding parts.

The articular eminences and cavities are moulded upon each other. This is also the case with the cavities destined to lodge soft or fluid parts, and the medullary cavities of the bones. Their existence and form are greatly dependent upon those parts which they contain. Thus the conformation of the skull, and that of the vertebral canal depend greatly upon that of the nervous centre which they lodge. The lower part of the vertebral canal, when empty, is triangular, just as the cotyloid cavity becomes when the head of the femur has been for a long time removed from it, both these parts being formed of three bony points.

§ 600. Be this as it may, the termination of evident growth, in length and breadth, depends upon the uniting of the long bones with their terminal epiphyses, and of the broad bones with their marginal epiphyses, or with each other. The termination of the growth in thickness depends upon the cessation of the osseous formation at the surface of the bones. This last kind of growth continues somewhat longer than the first.

The growth of the bones nevertheless continues to take place, but locally, and in an insensible manner, although sometimes in a manner which is still pretty sensible.

The sensible growth depends upon a kind of juxta-position at the extremities, edges, and surfaces of the bones. The insensible growth, on the contrary, is interstitial, and depends upon a true intus-susception. Striking examples of the latter are seen in some morbid cases especially; in empyema, spina-ventosa, &c.

§ 601. The growth being terminated, the bones remain the seat of a habitual supply or nutrition. Deposition and absorption go on very slowly and in an insensible manner in them in the state of health, and especially in old age. But in certain cases of disease, very decided changes take place in the properties of the bones, which clearly show that changes not less great are operated in their composition.

§ 602. The facts relative to the growth and habitual nutri-

tion of the bones, are especially proved by the effects of madder upon them.

Mizauld first,* and Belchier† a long time after, were the first who observed that when madder (*Rubia tinctorum*,) is given to animals mixed with their food, their bones become red. Duhamel, Boehmer,‡ Detlef,§ J. Hunter,‖ and several others have made curious experiments on the same subject. Rutherford¶ has explained the effect of madder on the bones alone, and to the exclusion of all the other parts of the body, by a chemical affinity of the colouring matter of madder for the earthy substance of the bones.

Duhamel found, in his experiments, that the bones of young animals are coloured much sooner than those of old animals; that the progress of their tincture and ossification is so much the more rapid the more vigorously their growth goes on; that when the madder is discontinued, the bones become white again, and that the return to their original colour is effected by the superposition of white layers upon the red. This last fact is also fully demonstrated by Hunter's experiments. Duhamel, however, imagined, notwithstanding these decisive experiments, that the bones enlarge in thickness by extension.

As to the growth in length, Duhamel's experiments also led him to think that this growth, which he compares to vegetation, takes place by the extension of their parts. It is proba-

* Ant. Misaldus. *Centur. Memorabilium seu arcanorum omnis generis*, 1572.

† Philos. Trans. vol. xxxix. 1736.

‡ *Radicis rubiæ tinctorum affectus in Corp. Anim.* Lips. 1751.—*Ejusdem prolusio, quâ callum ossium a rubiæ tinctorum radicis pastu infectorum describit. Ibid*, 1752.

§ *Ossium calli generatio et natura perfracta in animalibus rubiæ radice pastis, ossa demonstrata.* Goet. 1753.

‖ Exper. and observ. on the growth of bones, from the papers of the late Mr. Hunter, by Ev. Home, in Trans. of a Society for Improvement, &c. vol. ii. Lond. 1800.

¶ *Disput. Med. Inaug. de Dentium Formatione et Structurâ*, &c. Auct. R Blake. Edinb. 1798.

bly so in slow and insensible growth, but the rapid elongation which takes place before the epiphyses become united, evidently depends upon an addition of bony substance to the end of the body of the bone, as is proved by the following experiment of Hunter's. The tibia is laid bare in a young hog, and perforated at the two extremities of the ossified body, the interval between the two holes being carefully measured. Some months after, when the growth has advanced, the same distance is found to exist between the two bones, and all the elongation that has taken place has been beyond the hole, at the extremities of the diaphysis.

These experiments, which leave little to be desired with respect to the growth of the bones, do not by any means afford results so satisfactory respecting the habitual nutrition of the bones. To redden the bones of a young animal, it is sufficient to give it a few drams of madder, during a period of some days, while the same substance given in greater quantity, and during weeks or months, to an adult animal, hardly imparts any colouring to them.

§ 603. After the growth in extent has ceased, the bones still undergo farther changes, the most remarkable of which is their decrease.* The medullary canal of the long bones continues to increase in diameter from the moment of their formation. So long as the growth in thickness continues, the walls of the canal being augmented at the exterior, preserve their thickness, and even increase in that direction.

Duhamel made a very curious experiment on this subject, although he drew false inferences from it. Having laid bare and surrounded with a metallic wire a long bone of a young animal which he killed some time after, he then found the wire covered over by the bone which had increased in thickness, and the canal, having acquired the diameter of the metallic ring, he concluded from this circumstance that the bone had enlarged by expansion, by the widening of its canal. This is not the case, however. The bone had increased at its ex-

* Albinus. *Annot. Acad.*—F. Chaussard. *Recherches sur l'organ. des vieillards.* Paris, 1822.

terior by addition, and diminished at the interior by abstraction, whence resulted the enlargement of the canal.

In fact, when the growth of the bone in thickness is accomplished, the canal continuing to enlarge by internal absorption, its walls become thin in a singular degree, insomuch that, after having been thicker in the child than the diameter of the canal, and in the adult nearly as thick, they present in old age but a very small fraction of that diameter. The spongy cavities of the short bones, of the broad bones, and of the extremities of the long bones, generally enlarge in the same manner, so that, by this diminution of the substance of the bones, the skeleton of aged persons is rendered much lighter than that of others.

The broad bones of the skull pretty frequently undergo a diminution in thickness of another kind in old age. It results from the absorption of the diploe, and the approximation of the outer table to the inner, so as to produce at the same time a great diminution of thickness and an external depression. It is in the parietal prominences which are frequently affected by it, that this wasting generally commences.

Frequently also, in old age, the articular surfaces of the bones of the inferior members and the faces of the vertebræ are widened and flattened, as if they had at length yielded to pressure.

§ 604. The form of the bones is not the only property that undergoes changes from the advance of age. Their consistence also exhibits remarkable changes; the bones of children are more flexible and less brittle than those of adults, and may be bent or twisted in the living subject without breaking. Those of old persons, on the contrary, are denser, harder, and more brittle than those of adults, which circumstances, added to their having become thinner, renders fractures very common in old age. There is also a sensible difference in the proportion of the earthy substance, it being greater in old age than in the adult state.

Thus, after the growth in dimensions has terminated, the increase of the density continues in the bones, as in all the other parts of the body.

§ 605. Accidental ossification* is of very frequent occurrence, and was known at a very early period. This ossification is rarely perfect, and may in this respect be distinguished into several varieties.

The least perfect kind of accidental ossification is called earthy. It produces a white, opaque, chalky, soft, friable, and even sometimes semi-fluid substance. It is composed of animal matter, in small proportion, and earthy substance, and is commonly met with in cysts. Phlebolites are sometimes of this kind. It also occurs in isolated and formless fragments, in abscesses, in the lungs, in the fibrous body of the uterus, in the cellular tissue, and in the ligaments of persons affected with gout, in the brain, &c. Lastly, it is frequently met with infiltrated in the bronchial glands, the lungs, the liver, the kidney, the heart, &c.

The stony accidental ossification is of very frequent occurrence. It is very hard, opaque, and contains a greater proportion of earthy substance than the bones in their natural state. It is often met with under the form of a more or less thick incrustation under the serous membranes, in the proper membrane of the spinal marrow, and especially in the walls of the arteries. It also occurs under the form of cysts. It is observed under the form of isolated masses in the fibrous bodies of the uterus which have been ossified, and in the pineal gland, where it constitutes the substance called *acerbulus*. It is also sometimes met with under the form of infiltration of the pancreas. What has been described under the name of petrifaction of certain organs, or of the fœtus, is nothing else than an infiltration of very compact stony bone, so as to cause the animal matter of the organ to disappear almost entirely.

The accidental production sometimes differs still more from the bones, resembling in hardness and polish the enamel of the teeth. This accidental enamel sometimes replaces certain diarthrodial cartilages.

Accidental ossification sometimes greatly, or entirely, re-

* J. Van Heckeren. *De osteogenesi præternaturali.* Lugd. Bat. 1797.—P. Rayer. *Mém. sur l'ossification morbide,* in *Archives Génér. de Méd.* t. i. Paris, 1823.

sembles the natural bone, in its periosteum, its medullary spongy cavities, its texture, its semi-transparency, and its chemical composition; but this perfect production is of rare occurrence. It has been met with under the form of an isolated body in the dura mater. I have also seen it, but almost entirely compact, under the form of laminæ, situated in the anterior vertebral ligament. The bony plates which cover the costal cartilages are of the same nature. There is also sometimes observed a perfect, but compact, ossification, under the form of the hydatiferous cyst.

Accidental ossification, which also presents several varieties, is often an effect of age. Many old persons, however, are not affected with it. Its causes are most commonly irritation and chronic or latent inflammation. It is more frequent in cold than in warm countries. It commences with a plastic production, and sometimes passes through the semi-cartilaginous or fibrous states, but at other times does not. In general, it produces no inconvenience except by its bulk or mechanical effects.

The transformation of permanent cartilages into bone may be regarded as intermediate between natural and accidental ossification.

§ 606. Exostosis* is also an accidental bony production, sometimes perfect, and often stony, and resembling ivory. The periosteum being irritated or inflamed, there takes place, at its inner surface, in its substance, and in a part of greater or less extent of its breadth, a deposition of soft, organizable matter; it constitutes periostosis, which terminates variously. In many cases it ossifies, constituting at first a kind of epiphysis or bone, distinct and separable from the natural bone, to which the exostosis is at length firmly attached. Sometimes it consists of a very circumscribed nodus, which has been rapidly developed. At other times it forms slowly, and consists of a voluminous and foliated mass. Sometimes, also, a whole limb, or even a larger portion of the skeleton is affected by it.

Spina-ventosa, in place of always consisting of a morbid

* On Exostosis, by M. A. Cooper, in Surgical Essays, Part I. Lond. 1818.

production, is sometimes formed of organizable substance, which after having distended and dilated the natural bone, at last ossifies more or less completely in its interior.

§ 607. When a bone is denuded of the periosteum,* if the subject is young, if the bone itself be not altered, and if it has not remained long uncovered, the wounded soft parts, if restored to their natural position, unite by first intention.

Under contrary circumstances, and in those in which the inflamed periosteum separates from the bone by suppuration, in that in which it becomes gangrenous, and when the periosteum suppurates or mortifies, &c. the bone, deprived of its nutritive apparatus, becomes affected with necrosis at its surface, and to a greater or less depth. The living part in the vicinity of the dead portion, becomes inflamed, softens, is at length detached from the part affected with necrosis, and suppurates. The dead portion having thus become free, falls off. The subjacent granulations at length produce a cicatrix which covers the bone, adheres to it, and forms a new periosteum.

§ 608. After amputation,† matters go on in one or other of the two ways above described.

When the bone and its nutritive apparatus have not been hurt above the amputated place, and especially when the union of the wound is immediate, the end of the bone commonly unites by first intention with the soft parts.

On the contrary, when the wound remains open and suppurates, when the periosteum has been torn or detached above the place of amputation, or when the medullary membrane has been irritated and inflames, the end of the bone becomes affected with necrosis, and there is detached a slice comprehending its whole thickness, and generally gaining obliquely upon its outer surface, because the periosteum is commonly more injured, or is injured higher than the medullary membrane.

* Tenon. Three Memoirs on Exfoliation of the Bones, in *Mem. et Obs. sur l'Anat. Pathol. et la Chir.* &c. Paris, 1816.

† Van Horne. *Dissertatio de iis, quæ in partibus membri, præsertim osseis, amputatione vulneratis, notanda sunt.* Lugd. Bat. 1803.—L. L. Brachet, *Mém. de Phys. Path. sur ce que devient le fragment de l'os après une Amputation,* in *Bullet. de la Soc. Méd. d' Emul. de Paris,* 1822.

In both cases, moreover, the end of the bone ultimately undergoes other changes. In general, it becomes greatly diminished in volume and weight. The canal, which is at first filled by the spongy rarefaction of the compact substance, is re-established, but is closed at the extremity by a bony production placed over it like a lid.

§ 609. Deep necrosis* of the long bones presents at the same time interesting phenomena of separation and osseous production.

When the medullary membrane of a long bone is destroyed in a living animal, by introducing into its canal a foreign body which tears or cauterizes it, the whole limb to which the bone belongs swells, becomes painful, and has its temparature increased. At a later period abscesses form, which open and remain fistulous. There is seen, or felt through the openings, a moveable bone in the midst of the pus, and contained in another bone which is hollow. The internal bone, which becomes in time more and more loose, sometimes gets engaged by one of its extremities in one of the apertures of the external bone, and is even at length expelled. It is then seen to have the length of the diaphysis of the original bone, and a variable thickness, but which sometimes entirely equals that of the original bone. The new bone, however, being freed of the foreign body, and being connected from the commencement with the extremities of the old bone, which are now become its own extremities, gradually contracts within itself. The suppuration diminishes, and at length entirely ceases, when the walls, which have approached each other to such a degree as to touch, are agglutinated together, and at length become entirely confounded.

* Chopart and Robert. *De Necrosi Ossium Theses Anatomico-Chir.* Parisiis, 1766.—Troja. *De Novorum Ossium, &c.* Paris, 1775. Blumenbach, in Richter, *Chir. Biblioth.* B. VI.—David. *Observ. sur une Maladie Connue sous le nom de nécrose.*—Koeler. *Experimenta circa regenerationem ossium.* Gotting. 1786.—J. P. Weidmann. *De Necrosi Ossium. Franc. ad Mœn.* 1793, fol.—Russel. *Practical Essay on a Certain Disease of the Bones called Necrosis.* Edinb. 1794.—A. H. Macdonald, *de Necrosi ac callo.* Edinb. 1799.—Macartney, *in Crowther's Pract. Obs. on the Diseases of the Joints.* Lond. 1808.—Charmeil. *De la Regeneration des Os.* Metz. 1821.

The new bone, which is at first very soft and flexible, to such a degree as sometimes to be bent by the action of the muscles, when the old bone, engaged by one extremity in one of the fistulous openings, no longer forms a solid support to it, ultimately acquires and preserves a density and hardness superior to those of the original bones.

The medullary cavities form in the new bone in proportion as its tissue, which is at first uniformly lax, acquires density at the exterior.

All these changes take place as if spontaneously in the human species, in circumstances and under the influence of causes which appear to act upon the periosteum to produce inflammation in it, and probably also upon the medullary membrane, that is to say, upon the internal nutritive apparatus, in such a manner as to alter its texture and functions.

The long bones, in which necrosis occurs most frequently, are the following, being arranged nearly in the order of their frequency: the tibia, femur, the humerus, the mandibular bone, the bones of the fore-arm, the clavicle, the fibula, and the bones of the metatarsus and metacarpus.

Two theories have been proposed on this subject, the authors of which have only erred in making them exclusive, for things sometimes take place in the one way and sometimes in the other.

Troja, David, Bichat, and many others, have admitted that the sequestrum is formed by the entire body of the original bone rendered more or less thin by absorption and by the solvent action of the pus, and that the new bone results from a new formation, of which the external nutritive apparatus, that is to say, the periosteum and its vessels, has furnished the materials, which being deposited in its substance, and especially in its internal surface, have passed through all the states of fluidity and successive hardening which the regular bones present, excepting that the bony hardening commences in many points at once.

Experiments made on living animals show, that when the periosteum is torn off, it is reproduced along with the bone;

but the hardening of the latter is retarded during the whole of the time necessary for the reproduction of its vascular envelope.

When things have thus occurred, i. e. when it is a new bone that is formed, the separated piece has the same volume and appearance as the original bone, presenting the same processes, impressions, lines, and inequalities.

Other pathologists, and in particular MM. Levillé, Richerand, and recently Dr. Knox,* maintain that in all cases, the necrosis in question is confined to an internal portion of the substance of the walls of the medullary canal, and that the new bone simply results from the outer part of the original bone which the necrosis has not affected, and which has only undergone changes of volume and consistence.

It is certainly so in many cases, and then the sequestrum has a diameter sensibly less than the original bone, and its surface is rough and uneven.

The extremities of the long bones become affected with necrosis, and are reproduced much less frequently than their body. It is not uncommon, however, to observe these phenomena at the upper extremity of the humerus. They have also been observed at the lower extremity of the bones of the forearm. I have extracted from the interior of a new bone the lower extremity of the tibia, which had become affected with necrosis after a fracture which happened two or three years previously. The articular cartilage was all that was wanting at this extremity.

The broad bones are also subject to necrosis, but their reproduction is rare or imperfect. The scapula, however, after being affected with necrosis, has been seen to be replaced by two other bones.

Necrosis of the short bones is much more common than is supposed. It commonly exists under the form of a sequestrum inclosed at the centre of the bone. This constitutes many of the alleged cases of caries of the bones of the tarsus, carpus, &c.

* Edinburgh Medical and Surgical Journal, 1822 and 1823.

§ 610. The bony substance of new formation by which the solutions of continuity in bones are united, is named *callus*.*

When a long bone is fractured, besides the rupture of the osseous substance, there takes place a rupture of the medullary membrane, and commonly also of the periosteum, as well as of the vessels of these membranes and of the bone. There results from these vascular and other divisions, a more or less considerable effusion of blood around and in the interval of the fragments. If the latter are kept in perfect contact, an agglutination is presently effected between them and between the other divided parts. There also supervene a swelling and distention of the soft parts that have been divided and of those which surround them, which become compact like inflamed cellular tissue. The marrow, at the place of the fracture, especially participates of this state. All these parts, and especially the agglutinating or organizable substance which distends them, successively ossify, and form at the exterior a bony ring of greater or less extent, the thickness of which diminishes from the centre or from the seat of the fracture towards the two extremities, and at the interior a fusiform bony mass. The bone, however, of which the two fractured portions are thus brought together, seems until now to be in no degree affected by the changes which are taking place around it. It is only from this period, and in proportion as these temporary external and internal ossifications diminish and disappear by absorption, that the agglutination of the fragments becomes converted into a permanent bony union.

Several pathologists, and in particular Bonn, Callisen, and J. Bell, have contented themselves with observing the facts without attempting to explain them. Numerous hypotheses, however, have been proposed for the explanation of these remarkable phenomena. Boerhaave, Haller, and Detlef, his dis-

* Duhamel, *Mém. de l'Acad. Roy. des Sc.* Paris, 1741.—Boehmer, *De Ossium callo*, Lips. 1748.—P. Camper, *Observationes circa callum Ossium Fractorum*, in *Essays and Observ. Phys. and Liter.* vol. iii. Edin. 1771.—Bonn, *De Ossium Callo*, &c. Amstel, 1783.—Macdonald, *op. cit.*—J. Howship, in *Med. Chir. Trans.* vol. ix. Lond. 1816.—Breschet, *Quelques Recherches Hist. et Experim. sur le cal.* Paris, 1819.

ciple, have admitted that the fragments are united by a glutinous or coagulable matter.

J. Hunter, Macdonald, and Howship, have thought that this organizable and agglutinating matter is furnished by the blood.

It is well known that Duhamel and Fougeroux have admitted that the periosteum furnishes a bony ring which unites the fragments. Blumenbach has given the figure of a human bone surrounded by a ring of this kind. M. Pelletan taught the same thing in his clinical lectures. Camper had observed that there are an external callus and an internal callus. Bichat, M. Dupuytren, M. Cruveilher, and others, have admitted that these external and internal ossifications are provisory.

Many pathologists, and especially Bordenave, Bichat, Richerand, Scarpa, &c. have maintained that the union of divided bones is effected by cellular and vascular granulations, like that of the soft parts, which is true in either case only where the division is external and suppurative, and not when it takes place, as well as the union, without external wound and without suppuration.

I have already elsewhere* remarked, that all that these hypotheses want, in order to be theories or exact expression of facts, is to be combined, or not to be exclusive. This was Troja's opinion, and is also that of M. Boyer, M. Delpech, &c.

In fact, in the uniting of a simple fracture, there take place in succession, agglutination of the fragments by an organizable fluid, the materials of which are furnished by the blood; ossification of a similar substance, infiltrated all round the fracture, both internally and externally; lastly, vascular and osseous union between the fragments themselves.

The periosteum, which, when it exists, appears to perform so important a part in the production of the callus, is no more indispensable here than in the reproduction after necrosis. It has been removed from the ends of fractured bones in birds, and has been reproduced at the same time that the callus formed.

Comminuted fracture of the long bones, and especially that

* A. Béclard, *Propositions sur quelques Points de la Médecine*, Paris, 1813.

which is produced by fire-arms, is accompanied, in its union, by a large and permanent osseous production. It is in this production especially, in the same manner as in exostosis, as well as in reproduction after necrosis, that a great mass of new osseous matter may be seen. After being fluid it becomes solid, soft, flexible, and elastic, so that it might almost be mistaken for cartilage. But this substance contains numerous bony points; and if the observation is made in an animal that has taken madder, it is found to be of a rose colour, or even red, which is never the case with cartilages. It afterwards becomes hard like a common bone, and even more so. This permanent bony tumour bears the name of *callus*.

§ 611. Wounds of the bones differ from fractures, in the state of the solution of continuity itself, and in its mode of reparation, which is different from that described above. The bony tissue being very hard, and possessed of little flexibility, a sharp instrument which cuts it obliquely really produces a multitude of small fractures in the fragment which it raises, just as happens to a chip of dry wood raised by the blow of a hatchet. As to the subsequent union of this cut, as that of a fracture with wound, it commonly does not take place until after an exfoliation, and by the formation of suppurating granulations.

§ 612. The loss of substance of the long bones, in young and healthy subjects, is followed by a more or less extensive, and sometimes complete reparation or production. In birds,* the periosteum may even be removed, together with a large portion of one of the bones of the fore-arm, and these parts are in time reproduced by a kind of vegetation of the two ends. In the human species, when the loss of substance of a bony cylinder is inconsiderable, and the disposition of the parts does not admit of the fragments being brought together, there is produced, by the sinking and elongation of the ends, a cartilaginiform fibrous substance, which does not acquire the hardness of bone in its whole extent.

These more or less advantageous results of the reproduction

* Charmeil. *Op. Cit.*

of a portion of bone that has been removed, have given rise to the practice, in certain cases, of cutting out portions of diseased bones in their state of continuity.*

§ 613. When the callus after having commenced is subjected to repeated motions of flexion, twisting, distention, &c. it remains flexible, as in the preceding case, or no union takes place at all, and the ends of the bones remain in contact. This is also the case when the ends of bones are separated by a slight layer of muscular tissue.

§ 614. The broad bones have a stronger power of reparation and reproduction than the long bones. After the bones of the skull have been trepanned, a production is formed which is seldom bony to the centre. After the same operation, if the separated bony operculum is reapplied, it sometimes unites.† The phenomena of reproduction are very imperfectly known in the short bones.

§ 615. The separation of the epiphyses‡ takes place, in young subjects, from mechanical causes, like fractures, and the parts thus separated unite again by means of a similar callus. Chronic inflammation of the joints of the long bones also sometimes, in children and young persons, causes the separation of their epiphyses, which are not yet united. Both of these kinds of separations are rare. A case of false joint, in consequence of the fracture of the neck of the femur, has lately been published as an example of separation of the epiphysis in an adult.

§ 616. When an aneurismal tumour meets with a bone in the course of its development, the latter is gradually destroyed in the place which is in contact with the tumour, without any residuum of its substance remaining. This destruction bears the appellation of wearing of the bones.

§ 617. The morbid anatomy of the bones§ has already given

* Roux, *De la Résection, &c.* Paris, 1812.—Champion, *De la Résection des os dans leur continuité.* Paris, 1815.

† Merrem, *Animadversiones, quædam, &c.* Giess. 1810.

‡ Reichel, *De Epiphysium ab ossium diaphysi diductione.* Lips. 1769.

§ A. Bonn. *Descriptio Thesauri Ossium Morbosorum Hoviani.* Amstel. 1783.—Ed. Sandifort, *Museum Anat. Acad. Lugduno-Batavæ.* Lugd. Bat.

rise to numerous works and engravings. It still, however, presents, on some points, many obscurities to be cleared up, which, perhaps, depend more than is imagined upon vague comparisons which have been made between the alterations of the bones and those of the soft parts in general, without specifying any tissue in particular. It is a point of anatomy and pathology which is highly worthy of attention.

§ 618. Original vices of conformation* are rare in the long bones; less so in the short bones; frequent in the broad bones; rare in the bones of the limbs; more frequent in those of the trunk, especially in the sternum and ribs; still more so in the bones of the head; and especially in those of the cranium; and more so in those of the arch than in those of the base.

The most common variations are observed in the reunions of the bones, then in their figure, then in the form of their holes, and, lastly, in their apophyses.

Most of these vices of conformation, like those of all the parts, appear to depend upon a defect of formation. Some of them, however, seem to depend upon an excess of formation. They are of rare occurrence in the bones and in the parts of bones which are first ossified, and, on the contrary, more common in the parts which form last.

§ 619. The bones are sometimes consecutively altered so as to be increased or diminished in size. Besides the spina ventosa and osteosteatoma, already mentioned, and which are merely a dilatation of the bones; the exostoses, whether external or internal, which are only the periostosis and the spina ventosa ossified; the bones are also sometimes the seat of a hypertrophy. The bone is then tumefied, and there is an interstitial deposition which keeps up or increases their original density. In all cases there is an augmentation of weight. At

1793.—C. F. Clossius, *uber die Krankheiten der Knochen.* Tubingen, 1798. —J. Howship, in Med. Chir. Transac. vol. viii. and x.

* Van Doeveren, *Observ. Osteol. varios naturæ luses in ossibus. hum. corp. exhibent; in Obs. Acad. Specim.* Lugd. Bat. 1765.—Sandifort, *de ossibus diverso modo a solitâ conformatione abludentibus, in Observ. Anat. Pathol.*, Lib. iii. and iv. Lugd. Bat. 1777-81.—Rosenmuller, *de ossium varietatibus.* Lips. 1804.

other times the swelling results simply from the rarefaction of the compact substance. The bone, which is less dense, and more voluminous, has not then sensibly increased in weight. I have in my possession a very fine specimen of this kind of alteration, symmetrically occupying the two parietal prominences in a skull of a young subject: the bone, which is greatly rarefied, is extremely vascular. These two kinds of tumefaction, when they affect the long bones, sometimes determine the contraction or disappearance of the medullary canal. This case has been described under the name of enostosis.* I presented to the Faculty of Medicine a skeleton in which almost all the bones present this alteration.

§ 620. Atrophy of the bones gives rise prematurely to changes similar to their diminution in old age.

In the Museum of the Faculty of Paris, there are long bones of a young man, in which the walls of the medullary canal are as thin as paper. This canal has been enlarged by internal absorption, while no formation has taken place at the exterior. Phthisis, when very slow, sometimes produces this alteration in the bones. It is also produced by long inaction.

§ 621. Inflammation of the bones is very imperfectly known.

The term *caries* is one of the vaguest words in pathology. The obscurity of the thing has been increased by comparing caries to ulcers. What is most generally considered as caries, is a softening of the spongy substance of the bone, such that it can be cut with a bistoury without injuring its edge. This softening appears to be the effect of an inflammation, which generally terminates by suppuration, and also sometimes by necrosis.

Rachitis is another kind of softening which appears to depend upon the diminution of the earthy substance during the period of growth, whence results the bending of the bones under the weight of the body, and under the action of the muscles. In fact, if the bones of rachitic persons be examined at the period when they are soft,† it is found that the long

* Lobstein, *rapport sur les travaux exécutés a l'amphith. d'anat.* de Strasbourg, 1805.

† Ed. Stanley, in *Med. Chir. Trans.* vol. vii. Lond. 1816.

bones have become spongy in their whole thickness, and that their tissue, which has become soft and red, may easily be cut with the scalpel. On the other hand, when the disease is terminated, and the bones have resumed their hardness and inflexibility, the compact substance is found much thicker on the concave side of the curvature than on the opposite side; and when the bone is bent at an angle, the place at which the flexure exists is entirely compact, and the medullary canal is obliterated in it.

In the adult state, the softening depending upon the same cause, may proceed to the same extent, and even farther: the bones may become soft and pliant (*Osteomalacia, seu Malacosteon*); they may even acquire all the softness and flexibility of flesh (*Osteosarcosis*). At this extreme degree of softness, of which the woman Supiot presented an example so generally known, and in which the bones bend like soft wax, desiccation diminishes their weight and changes their form; decoction dissolves them; and their chemical composition is changed* to such a degree that they do not contain more than a few hundredth parts of earthy substance.

Lastly, it may happen, with, or without the preceding changes, that the animal substance of the bones loses its natural tenacity, and these organs, having become brittle, break under the slightest effort.

§ 622. Morbid accidental productions are also sometimes met with in the bony tissue; tubercles, scirrhus, and the encephaloid production are not uncommon in them.

SECTION II.

OF THE ARTICULATIONS.

§ 623. The Articulation, *Articulas*, 'Αρθρα is the joining of the bones. The term comprehends the manner in which they

* Bostock, in *Med. Chir. Trans.* vol. iv. Lond. 1813.—J. Davy, in Monro's Outlines of Anatomy.

meet, and are fitted to each other, and that in which they are mutually connected.

The long bones meet and are joined to each other by their extremities; the broad bones commonly by their edges; the short bones, by various points of their surface. The articular parts of the bones are most commonly prominences and depressions of different forms, and which are adapted to each other.

The means of union are cartilages, cartilaginiform ligaments, and fibrous ligaments. They are placed, either between surfaces which they connect, and thus render continuous, or around surfaces which remain in contact.

Articulations have for their common use, to connect the bones, and thus form them into a united whole, the skeleton.

Of the articulations some are moveable and others not so in a sensible degree; none of them, strictly speaking, however, is incapable of motion.

According to the form of the articular parts, the mode of union of these parts, and their solidity and mobility variously combined, the articulations are divided into three genera, and into several species and varieties, which have been uselessly multiplied; the synarthrosis, or continuous and immoveable articulation; the diarthrosis, or contiguous and moveable articulation; and the amphiarthrosis, or mixed articulation, which is continuous like the first, and moveable like the second.

Each articulation has a proper name, composed of the names of the bones which are united in it.

§ 624. *Synarthrosis*,* or the immoveable articulation, results from the union of all the bones of the skull and face, excepting the lower jaw, by edges more or less thick, and furnished with inequalities which fit into each other, often dovetailed, and always invested with a synarthrodial cartilage intimately united to the two articulated parts. The perioste-

* Duverney. *Lettre contenant plusieurs nouvelles observations sur l'ostéologie.* Paris, 1689.—F. G. Hunauld. Rech. *Anat. sur les os du crâne de l'homme.* Acad. des Sc. 1730.—E. G. Bose. *Program. de suturar. cranii humani fabricat. et usu.* Lips. 1763.—Gibson, on the use of sutures in the skulls of animals, in *Mem. of the Soc. of Manchester*, 2d series, vol. i. 1805.

um, in passing from the one to the other bone over the intervening cartilage, also unites these three parts, to which it intimately adheres. This kind of articulation, which is very solid, has no sensible motion. It favours the growth of the broad bones by their edges. It is often obliterated in old age. Its disunion requires efforts of the same kind and violence as those which fracture the bones.

This kind of articulation, which has received the generic name of suture, presents several varieties.

§ 625. The true suture is that in which the edges of the articulated bones present numerous and extensive eminences and depressions, which receive each other. Of this kind are the inter-parietal, occipito-parietal, and fronto-parietal articulations. This suture itself presents some differences. Thus, in the first, they are long tooth-like prolongations; in the second, they have the form of rounded tails; in the third, they resemble the teeth of a saw. These three varieties have received the names of dentate suture, *sutura dentata*, serrated suture, *sutura serrata*, and margined suture, *sutura limbosa.*

The harmonic articulation, is that in which the edges of the bone, which are more or less thick, present rugosities which are fitted to each other; the suture by which the nasal bones are joined to each other, is of this kind.

The squamous articulation is that in which the edges of the bones are sloped like a chisel, and fitted to each other like the edges of a bivalve shell. This disposition, which is very decidedly marked in the junction of the parietal and temporal bones, occurs combined with the suture or harmonic articulation in many other articulations of the skull and face. In many articulations, it is double and reciprocal, so that at one part, a bone overlaps the other, which in another part overlaps the first in its turn. Of this kind are the spheno-frontal sutures. This mortising is one of the most powerful means of ensuring the solidity of the synarthrodial articulations.

Schindylesis is a synarthrosis which results from the reception of the crest or ridge of a bone into the groove of another. Of this kind are the articulations of the sphenoid and ethmoid

bones with the vomer, the lachrymal bone with the nasal process of the maxillar bone, &c.

Lastly, Gomphosis is a species of synarthrodial articulation, entirely different from the suture, which results from the reception of the roots of the teeth into the alveoli.

§ 626. *Amphiarthrosis*,* or mixed articulation, partakes of the nature of synarthrosis in having the articular surfaces united by means of an intermediate substance, and of that of diarthrosis in having a considerable degree of mobility. This kind of articulation is confined to the body of the vertebræ, the pubis and the upper parts of the sternum.

The articular parts of the bones, are here flat and broad surfaces. The means of union are intermediate cartilaginiform ligaments, adhering very firmly to the two surfaces, and accessary ligaments placed at the exterior of the articulation. This kind of articulation, which is often called symphysis, possesses a great degree of solidity, which is owing to the tenacity of the ligament. Its mobility is owing to the flexibility and elasticity of the same substance. The motion consists of the flexion or torsion of the ligament. This articulation, which is very loose and mobile in childhood, becomes more and more firm in old age, at which period it sometimes ossifies. Sometimes the ossification is external to it, and only surrounds it more or less completely, as is especially observed at the fore part of the body of the vertebræ. It may be accidentally too loose or too close. It is not susceptible of a true luxation, but rather of a displacement, a drawing asunder, which always supposes the laceration or destruction of the intervening cartilaginous ligament.

After certain unconsolidated fractures, there are sometimes produced articulations of this kind; that is to say, the fragments are united by the intervention of a flexible and tenacious substance, which permits them to move upon each other. This mode of accidental articulations occurs after fractures of the patella, the neck of the femur, the olecranon, and also sometimes after those of the body of the long bones. Amphi-

* A. Béclard. *Dictionnaire de Medicine*, vol. ii.

arthroses also sometimes form in the place of some diarthroses, of which the synovial membrane has contracted flexible adhesions.

§ 627. *Diarthrosis* is a kind of articulation in which the articular surfaces of the bones are in contact, and move upon each other.

This kind of articulation exists among all the bones of the limbs, whether between each other, or between them and the trunk, between the lower jaw and the skull, between the skull and vertebral column, between the articular processes of the vertebræ, between the ribs and vertebræ, and between the costal cartilages and the sternum.

§ 628. The articular parts of the bones, in this kind of articulation, are broad surfaces, whose configuration is reciprocal. These surfaces are in general, the one convex, the other concave. The convex surfaces, or articular eminences, are sometimes rounded like a large segment of a sphere, in which case they are called heads. Others are rounded, but elongated in one direction, and contracted in another: these have been named condyles. The heads and condyles are sometimes supported by a narrow part, which is called the neck. The articular depressions, or concave surfaces, bear the name of cotyloid cavities, when they have the form of a segment of a sphere and are deep; and that of glenoid cavities, when they are more superficial. Sometimes two condyles are brought near each other laterally, and leave between them a neck which enters into the articulation like themselves. This kind of surface is named a pulley, *trochlea:* Lastly, many articular surfaces, which are nearly flat, presenting little convexity or concavity in their configuration, have received no particular name, but are designated, according to their extent, under the generic names of articular surfaces or facettes.

All these surfaces are covered with diarthrodial cartilages (554). These cartilages are themselves covered by synovial membranes (210), and moistened with synovia (216). There are, moreover, between certain of these surfaces, menisci or chondroid inter-articular cartilaginous ligaments (531.)

§ 629. The means of union are fibrous ligaments, (512.)

The muscles which surround the articulations, although they do not enter essentially into their composition, contribute powerfully to their solidity.

§ 630. Firmness and mobility are variously combined in the diarthrodial articulations.

These articulations possess very diversified motions, as sliding, rotation, angular opposition and circumduction. The sliding motion exists in all the diarthrodial articulations. The other motions, on the contrary, occur only in a cerain number of them. Rotation is peculiar to certain articulations. Sometimes it is exercised upon a single pivot, as around the odontoid process of the second vertebra. Sometimes there are two, as in the double articulation of the bones of the fore-arm with each other. Sometimes it is round an ideal axis that a bone turns, as is exemplified in the femur. The motion of opposition, or angular motion, is that in which the bones form more or less open angles with each other, according to the degree of motion. It is distinguished into opposition limited to two motions of flexion and extension, as at the elbow, the knee, &c.; and into vague opposition, which may take place in four principal directions, and in all the intermediate directions, of which examples are offered by the arm, the thigh, the thumb, &c. Circumduction, which exists in all the articulations possessing vague opposition, is a motion by which the bone which moves describes a cone whose summit corresponds to the central extremity of the bone, and the base to its opposite extremity.

The firmness of these articulations, like that of the others, is in the inverse ratio of their mobility.

§ 631. Several kinds of diarthrosis are distinguished, depending upon the configuration of the surfaces, the means of union; and the motions of these articulations.

The close and planiform diarthrosis, *articulus adstrictus*, the amphiarthrosis of some, the *motus obscurus* of Columbus, is that in which the surfaces are superficial, the ligaments strong and tight, the motions obscure and confined to sliding, but capable of being performed in several directions. Of this kind are the articulations of the articular processes of the ver-

tebræ, and those of the bones of the carpus and tarsus, whether with each other or with the metatarsus and metacarpus.

Arthrodia differs from the preceding articulation, in this respect, that the surfaces are less flat, the ligaments less tight, and the motions freer and more numerous. Of this kind is the temporo-maxillary articulation.

Enarthrosis consists in the reception of a head into a cavity. In this species the ligament is capsular, and the motions greatly diversified. The articulation of the femur with the coxal bone affords an example of it.

These three first kinds of diarthrosis are orbicular or vague. Their motions, which are more or less free, may take place in all, or in many directions. The following species, on the contrary, are called alternate, because the motions are performed in them only in two opposite directions.

The rotatory diarthrosis, *commissura trochoides* of Fallopius, is that which allows only motions of rotation; of which kind are the articulation of the atlas with the second vertebra, and that of the radius with the ulna. It is also called lateral ginglymus.

Ginglymus,* properly so called, or the hinge joint, also called angular ginglymus, is the articulation in which there are only two opposite motions, of which kind is the elbow joint. In this species of diarthrosis, one of the bones commonly presents a pulley, and the other a corresponding surface. There are generally two lateral ligaments. If the motion of extension is not to go beyond the line of direction of the bones, these ligaments, in order to limit the motion, are placed nearer the plane of flexion than the opposite plane.

§ 632. Accidental diarthrodial articulations are produced under two different circumstances, after fractures of which the pieces have not united, and after luxations which have not been reduced. Both are very complex productions. The first kind may be called supernumerary, the other supplementary articulations.

* I. F. Isenflamm and Schmidt. *De Ginglymo.*—Erlangæ, 1785.

§ 633. The supernumerary articulations* have long been known. They occur after fractures in which the fragments have not been brought together, and those of which the fragments have been frequently moved on each other. Sometimes also the defect of union depends upon a constitutional affection. The ends of the bones, which have a different configuration, and have become compact and closed as after amputation, are covered with a thin layer of imperfect or fibrous cartilage. They are covered and enveloped by a synovial membrane, surrounded by a fibrous capsule, generally incomplete and with irregular ligamentous cords. This kind of articulation has been observed, with a great number of variations, in almost all the long bones of the limbs, and several times in the lower jaw and ribs.

§ 634. The supplementary articulations have also been often observed. They follow unreduced luxations, and especially those of the femur and humerus. Foville and Pinel Grandchamp presented me with an anatomical preparation which represents an articulation of this kind that had been formed after an unreduced luxation of the bones of the fore-arm behind the humerus.

In the articulations of which we here speak, there occurs a depression in the point against which the head of the luxated bone rests. The circumference of this point is raised by an accidental ossification. Sometimes even there also occurs a circular fibro-cartilaginous rim in it. This newly formed cavity is covered with an imperfect or fibrous cartilage. The head of the luxated bone is commonly flattened. The interior of the articulation is lined by a very distinct synovial membrane and moistened by synovia. There is a fibrous capsule, formed by the remains of the old capsule, adhering to the luxated bone, by the surrounding cellular tissue, and by a new production. The old cavity contracts and becomes superficial, and the cartilage diminishes, or even entirely disap-

* J. Salzmann. *De Articul. Analogis, quæ fracturis Ossium superveniunt.* Argentor, 1718.—Langenbech, *Uber die Bildung wider naturlicher Gelenke nach Knochenbruchen, in der Neuen Bibl. fur die Chirurg.* Gotting. 1815.

pears. If it is in the haunch, the cotyloid cavity diminishes, and from being hemispherical becomes triangular; a fact to be added to those which show that the form of organs depends, partly at least, upon their reciprocal action. It would appear that these changes were in part known so early as the time of Hippocrates.

§ 635. M. Chaussier* has produced, in dogs, the formation of accidental articulations intermediate between the two kinds above described. Having by an incision made the head of the femur to come out of the cotyloid cavity, and having sawn it below the trochanter, he brought the flesh together, and left the animals to the care of nature. On examining the parts at periods more or less remote, he found that the muscles had drawn the extremity of the femur near a part of the ischium; that the truncated bony extremity was rounded, and invested with a cartilaginiform substance; that the point of the ischium against which it rested had also assumed a cartilaginous appearance, and sometimes presented an articular fossette of greater or less depth; lastly, that the cellular tissue formed around this new articulation a kind of membranous capsule, in which was contained a serous fluid in greater or less quantity.

§ 636. The diarthrodial articulations may be altered in their solidity and in their mobility; they may be too loose or too tight, and they may also be luxated or anchylosed.

§ 637. Luxation is the more or less complete cessation of the natural connexion between the contiguous surfaces of bones. When it takes place, the ligaments are violently stretched, drawn out, or even ruptured. The other articular and surrounding parts are more or less affected by these lesions. Motion is then very difficult. The most mobile articulations are the most susceptible of it. Thus the arthrodiæ and enarthroses are those which present the greatest number of examples of it, and the close diarthroses those which present the fewest. Of the articulations of the same species, those which are the least close, those whose articular surfaces have the

* *Bulletin des Sciences par la Soc. Philom.* Paris, an. viii.

smallest extent, and those which take place between the longest bones, are those which are most frequently luxated. Thus, the shoulder-joint furnishes of itself more examples of luxations than all the others together.

§ 638. Anchylosis,* or the uniting of the diarthrodial articulations, consists, when it is complete, of an intimate union, a real continuity between bones which were previously in contact. The spongy substance communicates from the one bone to the other. The compact plates, the diarthrodial cartilages, the synovial membrane and the synovia, which separated the spongy part of the two bones, have disappeared. Immobility continued for a great length of time, but especially a certain degree of inflammation, whether originally in the synovial membrane, or at first in the ligaments and the other surrounding parts, induce these changes. Sometimes they commence by an agglutination of the synovial membrane, and the formation between its surfaces of cellular tissue or fibrous bridles which may become ossified at a later period. Sometimes the articulation being laid open by a wound or the effect of an abscess, it is by suppurative granulations that the agglutination is established. In both cases, the diarthrodial cartilages are gradually absorbed before the osseous union takes place. All the diarthroses are susceptible of anchylosis, but the ginglymi more than the others.

Anchylosis sometimes affects several articulations. All the diarthroses and amphiarthroses have even been seen to be successively affected by it, and the skeleton has thus become a single inflexible mass. M. Percy has deposited in the Museum of the Faculty of Paris a skeleton which presents this general anchylosis of all the articulations.

§ 639. At other times, the causes of alteration of which we speak determine the superficial necrosis or wearing out of the articular surfaces. It is in cases of this kind that excision of the articular extremities of the bones has been practised.† At

* J. Th. Van de Wympersse. *De Ancylosi*, &c. Lugd. Bat. 1783. Idem. *De Ancyloseos Pathol. et Curat.* Lugd. Bat. 1783.—J. Cloquet, in *Dictionnaire de Médecine*, vol. ii.

† H. Park. *Account of a New Method of Treating Diseases of the Knee*

other times, the adhesion of the articulation remains cellular or fibrous, with a little mobility. Sometimes the destroyed cartilage is reproduced. At other times it is replaced by the transformation of the subjacent bony plate into ivory or enamel. In cases of this kind spontaneous luxation of the bones sometimes occurs.

I have seen a singular displacement of the hip-joint, depending no doubt upon chronic inflammation. In this case the upper part of the articular cavity seems to have yielded to the pressure of the head of the femur, after having been softened. The cavity, which has become oval, is greatly elongated and hollowed out at its upper part, where it lodges the head of the femur, while the lower part of the same cavity which lodged it before is contracted and superficial. I have observed this change sometimes on one side only, and sometimes symmetrically produced on both sides at once.

§ 640. All the diseases of the diarthrodial articulations belong to each or to several of the parts of which they are formed, to their serous membranes, their cartilages, their ligaments, and to the articular parts of the bones.

SECTION III.

OF THE SKELETON.

§ 641. The skeleton is the aggregate of all the bones connected with each other by the articulations. It is called natural, when the bones are kept together by their proper ligaments, and artificial, when the bones are united by substances foreign to the organization.

It constitutes a symmetrical whole,* which has the form and

and Elbow. London, 1783. Moreau, *De la Résection des Os*. &c. Paris, 1816. J. Jeffray.—*Cases of the Excision of Carious Joints*, by H. Park and P. F. Moreau, *with observations*. Glasgow, 1806.—Wachter. *Diss. de Articul. Extirp.* Groningue, 1810.—Roux, *De la Résection*, &c. Paris, 1812.

* Loschge. *De Sceleto Hum. Symmetrico*, &c. Erlang. 1795.

dimensions of the entire body, which dimensions it in a great measure determines.

It is divided into the trunk and limbs. The trunk, the central and principal part, and which is formed in the median line by the vertebral column, presents two great cavities. The one, which is superior and posterior, and is formed by the skull and vertebral canal, lodges the nervous centre; the other, which is anterior and inferior, and is formed by the thorax, lodges the central organs of the nutritive functions. Other cavities (those of the face), receive the organs of sense, &c. The appendages or limbs which are furnished with numerous articulations, possessed of great mobility, are especially subservient to motion.

§ 642. The uses of the skeleton are to form the solid and flexible axis of the body, furnish protecting envelopes to the nervous and vascular centres, and to the organs of sense, afford points of attachment to the muscles, and determine by its articulations the extent and direction of the motions.

The skeleton performs part of its functions through the hardness and rigidity of the bones, and the solidity of the articulations. The rest it performs through the mobility of the articulations.

§ 643. In their motions, the bones articulated by diarthrosis act in the manner of levers.

The greater part are levers of the third kind, or that in which the power is interposed between the fulcrum and weight. The centre of motion or fulcrum is in the articular extremity of the bone, the resistance or weight at the other extremity, and the muscular power is applied in an intermediate point, which is commonly very near the fulcrum. Some of them are levers of the second kind, or that in which the weight is intermediate between the fulcrum and power. Some also are levers of the first kind, in which the fulcrum is interposed between the weight and the power.

§ 644. As the bones are not all formed at the same time, and do not all grow in the same proportion, the form and pro-

portions of the skeleton, and not merely its dimensions undergo great changes through age.*

The proportion of the head to the rest of the trunk and to the limbs is so much the greater, the younger the subject is, only within the twentieth year. At the second month after conception, it forms half the height of the body, nearly the fourth at birth, the fifth when three years old, and the eighth only when the growth is complete. The face in like manner is so much the smaller, compared with the skull; the pelvis, compared with the thorax, the limbs compared with the trunk, &c. the younger the subject is. Many other differences of the same kind will be pointed out in the particular anatomy of the bones.

§ 645. The skeleton presents pretty distinct differences in the two sexes.† In general the skeleton of the female is smaller and more delicate than that of the male; the thorax is shorter, and altogether smaller; it is also more mobile; the pelvis broader; the lumbar region more elongated, &c. The diarthrodial articulations are more mobile, the amphiarthrosis more flexible, &c. All the regions of the body, and almost all the bones, present some particular differences.

§ 646. The human races also present differences in their skeleton, the principal of which have reference to the dimensions and form of the skull, and its proportion to the face.‡ There are also some differences in the proportions of the limbs. In the negro race, the upper limbs are longer in proportion to the trunk; the fore-arm and leg are longer proportionally to the arm and thigh.

§ 647. Lastly, individual varieties are observed in the

* Boehmer. *op. cit.*—Cheselden, *op. cit.*—Eyson, *op. cit.*—Sue, *Sur les Proportions du squelette de l'homme, examiné depuis l'âge le plus tendre, jusqu'à celui de vingt-cinq, Soixante ans et au-delà;* in *Mém. Prés.* vol. ii.—F. G. Danz, *Grundriss der Zergleiderangskunde des ungebornen kindes,* Francoff, 1792.—Senff, *op. cit.*

† See J. F. Ackermann, *De Discrimine Sexus preter genitalia.* Mogunt, 1788.—Compare also Albinus, *Tabula sceleti hominis,* and Soemmering, *Tabula sceleti fœminei,* Francof. ad Mœnum, 1796.

‡ Blumenbach, *Decades Craniorum,* i.-vi.—Soemmering, *De Ossibus.*

skeleton, both with respect to dimensions, and with reference to proportion, configuration, want of symmetry, &c.

The stature of the body, which is determined by the dimensions of the skeleton, is about five feet four inches in the adult man, and about five feet in the female; but this length, which varies somewhat in the different races, and even in still more restricted varieties of the human species, presents considerable differences in the individuals of the same race or nation. These differences, like those of the other species of animals, are confined within certain limits. Thus, dwarfs are seldom of less than half the mean stature, and giants are very seldom more than a half higher than the ordinary stature. What has been said of giants from seventeen to twenty-five feet high, must be referred to bones of animals mistaken for human bones.

The proportions which the limbs bear to the trunk and its different parts, or those of the limbs to each other, also present numerous individual varieties, determined by those of the bones. This is also the case with the general configuration and symmetry of the body, their variations being almost all determined by those of the skeleton.

§ 648. The osseous system terminates the systems which have for their basis the mucous substance or the cellular tissue variously modified. The tissues which remain to be described are, on the contrary, essentially formed of globules united by the same substance.

CHAPTER IX.

OF THE MUSCULAR SYSTEM.

§ 649. The muscular system,* *systema musculare*, comprehends all the organs formed of long, parallel, soft, irritable and contractile fibres, which are of a reddish colour in warm blooded animals, and are called muscular; these organs produce all the great motions which take place in living bodies.

The name of muscle, *mus*, μῦς, from μύειν, to contract, indicates this property; the muscles are in fact the organs of motion.

§ 650. It may appear astonishing, but it is nevertheless true, that the first anatomists, Hippocrates and Aristotle, were unacquainted with the muscles and ignorant of their uses. The anatomists of the Alexandrian school were acquainted with these organs, and have mentioned some of them. Galen had a pretty accurate knowledge of them; he represents the muscle as formed by the nerve and by the ligament divided into fibrils, forming a tissue which he calls *stœbe*, the interstices of which are filled with flesh; he supposes the muscles to be endowed with a tonic faculty, or contractile force, and in a state of elastic tension, inherent in their tissue and independent of life; movement would depend, in that case, on the voluntary relaxation of the antagonist muscles.

* W. G. Muys, *Investigatio fabricæ, quæ in partibus musculos componentibus extat.* Diss. i.; *de carnis musculosæ fibrarum carnearum structurâ*, &c. Lugd. Bat. 1741, 4to, clij. et 432 p.—Prochaska, *de carne musculari tractatus anat. physiol.* Viennæ, 1771; *et in op. min.* pars. i.; Viennæ, 1820.—F. Ribes, *Dictionn. des Sc. Med.* articles *muscle, musculaire, et myologie.*

In his time a voluntary contraction more prompt and more extensive than this contraction by elasticity was also admitted. At the epoch of the revival of the sciences, myology was still in the very imperfect state in which it had been left by Galen; it is indebted to James Dubois (*Sylvius*) for considerable advancement: he named most of the muscles, which had previously taken place only with respect to a very small number of them. Vesalius, and the other anatomists of the Italian school, Eustachi especially, have perfected the knowledge of the muscles, and have figured them. The intimate texture of the muscles, their contractile action, the nervous influence of this action, and the movements which result therefrom, have been sedulously studied during the course of the two last centuries, and are still the subject of important labours.*

§ 651. In the more simple animals, the muscular fibre is not distinctly perceived: in them movements are produced by the cellular tissue. In the first of the series where the muscular fibre appears, it only moves the tegumentary membranes to which it is annexed or of which it forms a part. In all those which possess a heart, this fibre is the principal element of this organ. Lastly, in the vertebrate animals, a few muscles only are attached to the mucous membrane, to the skin, and to the senses, their dependencies; a great number, on the contrary, are attached to the skeleton, in order to move it.

§ 652. In man there are two classes of muscles: the first, interior, membraniform and hollow, appertaining to the mucous membrane and the heart, contracting involuntarily, and subservient to the functions of nutrition and of generation, in a word, to the vegetative functions; the second, exterior, more or less thick and full, belonging to the skin, to the senses, to the skeleton, and to the larynx, contracting voluntarily and subservient to the animal functions. Both classes present characters common to each other, which it is necessary to consider generally.

* Messrs. Prevost and Dumas are making observations on the intimate texture of muscles and on muscular action. They have had the goodness to communicate to me the first results, as yet unpublished.

SECTION I.

OF THE MUSCULAR SYSTEM IN GENERAL.

§ 653. The muscular system forms of itself a great portion of the weight and volume of the body.

§ 654. However diversified may be their form and situation, the greater part of the muscles are divided into bundles, and are all formed of primitive or simple fibres, collected into fasciculi.

The authors who have treated on this point of minute anatomy, have in general presented it in a manner but little intelligible: some simply observe, that the flesh is composed of fibres; others, of fleshy striæ; others again, of fibres and fibrils; and lastly, others state that it is composed of fibres, themselves composed of villi. Muys has made a ternary division. He divides the muscular flesh into fibres, fibrils and threads. He subdivides the fibres into three orders: large, mean and small; the large being composed of the mean, and the latter of the small fibres; the same with respect to the fibrils, the smallest of which compose the mean, and these compose the largest, the latter composing the smallest of the fibres; the same again as to the threads, of which the most minute of the fibrils are composed; according to this doctrine, the muscles would be the result of nine successive degrees of composition.

Others, rejecting this analysis as altogether imaginary, admit an infinite divisibility. But it is well established, on the contrary, that, with respect to the muscles, as with all organic substance, we arrive by microscopic inspection, at a degree of division finite and well determined.

§ 655. The muscular bundles, *lacerti*, are not equally distinct, numerous and voluminous in all the muscles; the bundles composing some of them, are so distinct and large that they may be considered as so many particular muscles: such are the portions of the biceps, triceps, the bundles of the deltoid, of the masseter, of the glutæus magnus, &c.; such are also

the fleshy columns of the ventricles of the heart, the longitudinal bands of the colon, &c. There are, on the other hand, many of the muscles which scarcely equal a small portion of a bundle of which the preceding are composed, and which are not formed of distinct bundles.

The muscular bundles are themselves formed of bundles less voluminous, and these latter of others still more minute, which may be distinguished in almost all the muscles.

§ 656. All the muscles may moreover be divided into fasciculi or fibres visible to the eye, *fasciculæ seu fibræ secundariæ*. These fasciculi, the ultimate degree of division perceptible to the naked eye, have, in all the muscles, nearly the same form and the same thickness. They may, according to the preceding divisions, be perceived by a longitudinal dissection, but still better by a traverse section, and especially in a muscle boiled or steeped in alcohol. They have a prismatic, pentagon or hexagon form, and never a cylindrical one; their diameter varies a little; their length, according to Prochaska, is equal to the entire extent of the interval between their two attachments, even in the sartorius muscle. Haller, on the contrary, thought with Albinus, that the fibres or the fasciculi were not so long as the muscles, and that fasciculi of fibres terminated by tapering off in the intervals of other similar parts; this does not appear to be the case.

§ 657. The muscular fibres, *fibræ musculares primariæ, seu fila carnia*, visible only by the aid of the microscope, are the ultimate degree of anatomical analysis of the muscles. We are indebted to Hooke, R. Leuwenhoeck, Dehayde, Muys, De la Torre, Prochaska, Wenzell, (Brothers,) M. Autenrieth, M. Sprengel, Messrs. Ed. Home and Bauer,* and to Messrs. Prevost and Dumas,† for the best observations on this subject. It must be remarked, however, that the first of these observers having in their researches only made use of lenses which magnified about 150 times, were not enabled to perceive the pri-

* Croonian Lecture, in Philos. Trans. ann. 1818.

† *Examen du sang et de son action dans les divers Phénomènes de la Vie; in Annales de chimie et de Phys.* t. xxii.

mitive fibres, which require, in order to be seen, to be magnified about 300 times; their observations therefore relate only to secondary fibres.

Hooke observed that the muscles of many animals are composed of an innumerable quantity of fine threads, the volume of which he estimates at the hundredth part of a hair, and compares its figure to that of a series of pearls or beads of coral. Leuwenhoeck, after having perceived the muscular fibres, which he calls primitive, conjectured that they were again composed, founding his idea, though incorrectly, on the supposition that spermatic animalcules, still more minute than fibres, must be provided with nerves and with muscles; he moreover delineated rough figures of them; those of Dehayde, though coarse also, are more exact. Muys has given descriptions of them equally long and exact, he represents them as most generally cylindrical, and seldom knotty. De la Torre says they are reddish, which is not generally true. The observations of Prochaska, which are much more exact, prove that these fibres are parallel but not always straight, and that in cooked flesh they are almost always flexuous; that their form is not cylindrical, but flat and prismatic; that their substance is diaphanous and appears to be solid; their diameter, with little variation, appeared to him to be seven or eight times less than the largest diameter of a red globule of blood. This observation, however, seems to be inaccurate; he considered these fibres as constituting the ultimate degree of the division of the muscles, without going so far as to affirm, however, that these are the elementary fibres. The microscopic observation made by the brothers Wenzell, on a portion of muscle previously immersed during eight days in a mixture of alcohol and muriatic acid, discovered to them that each fibre was composed of round and minute corpusculi. According to M. Autenrieth, the diameter of these fibres is the fifth of that of the globules of the blood. M. Sprengel, on the contrary, estimates the diameter of the muscular fibre at seven times that of a globule of blood, (which is the three hundredth part of a line) that is to say, at about the fortieth part of a line; he moreover describes it as angular, striated and full. The

microscopic observations of M. Bauer and of M. E. Home, published with very beautiful plates, represents the muscular fibre as identical with the particles of blood divested of their colouring matter, and the central globules of which have united in filaments. Messrs. Prevost and Dumas have uniformly obtained the same result, whatever may have been the animal submitted to their examination, or whatever may have been the form and volume of their globules; my own observations accord entirely with theirs. That the observation may be divested of all doubt, it ought to be made on raw and unprepared muscular flesh; in fact, coction and the action of alcohol produce globules by coagulating the albumen, and we may attribute their presence in the muscular fibre to these causes. These globules are united by a *medium*, invisible because of its transparency and want of colour; it is a kind of jelly or mucous. If muscular flesh be macerated in water frequently renewed, putrefaction changing more promptly the means by which the globules are united than the latter themselves, and the renewing of the water inducing the product of putrefaction, isolated globules are obtained similar to those of the coloured particles of the blood. The fibres of all the muscles have the same volume as well as form.

§ 658. Wrinkles or flexuosities are often perceived on the fasciculi of the muscles, particularly when boiled. This appearance was noticed by Hooke, Leuwenhoeck, Dehayde and Haller, was well delineated by Muys, and engaged the special attention of Prochaska, who attributes it to the contraction of the cellular tissue, vessels and nerves, and to their crispation by coction. These apparent wrinkles or striæ have also been ascribed to several other imaginary causes, and have produced the supposition that the fibres have an articulated, twisted or spiral disposition. These wrinkles are, or at least appear to be, nothing more than flexuosities or undulations; they always exist in contracted muscles, whether in the living, or in the dead subject, or by the action of caloric. This flexuosity is produced of its own accord when the retraction of a muscle is assisted, or when produced by cutting, by bringing its attachments towards each other, or by pushing them towards each

other; on the contrary, they disappear when the muscular fasciculi are extended in the dead subject. They disappear entirely when the cadaverous stiffness has disappeared.

§ 659. Some physiologists, deceived by incorrect observations, or governed by hypothetical views, have admitted false or entirely arbitrary opinions as to the intimate texture of the muscular fibre:* thus a great number of physiologists and mechanicians have admitted that the muscular fibre is hollow, and that it consists of a series of ovoid vesicles, or of rhomboidal cavities, elongated in a state of relaxation, but widened and globular when the muscles are in a state of contraction. Several have considered the muscular fibre to be hollow and continuous to the nerves. Many others have considered it as hollow, vascular and injectable, either as being formed solely of small arteries or as consisting of very minute vessels intervening between the small arteries and small veins. Others have described these interior cavities, both vesicles and canals, as spongy and cellular. Some have admitted transversal, nervous or other fibres, either intended to retain the blood in the fibre, or to close its dilated canal and to shorten it by this mechanism. Others again have imagined the fibres to be a spiral canal around a thread which is incapable of extension; while others have supposed it to be twisted like a thread of flax or hemp, &c.

It may be objected to all these assertions that the muscular fibre, when examined with good optical instruments, appears to be the result of a linear series of opaque globules, united by a medium more transparent, but that nothing is found to indicate that these globules are vesicles; that when the muscular contraction takes place, wrinkles are perceived to form, but these flexuosities are effaced as soon as the muscle is relaxed, no change at all, however, occurs in the figure of the globules; that in insects, in which no vessels exist, there are nevertheless muscular fibres which consequently can not be the continuation of them; that injection may indeed swell the muscles by infiltrating between the fibres, but that it does not penetrate

* Haller, *Elemento physiolog.* lib. xi, sect. i. et iii. tom. iv.

them; that the supposed transverse, twisted, and spiral fibres &c., have never been seen, but only imagined, in support of certain hypotheses in reference to muscular action; that in short, the muscular fibre, differing essentially in its organic character, and in its vital phenomena, from the cellular and nervous tissues, as well as that of the vessels, can not be assimilated to these tissues. Mascagni has revived and modified one of those opinions, by considering the primitive cylinders of the muscles as formed of absorbent vessels filled with a contractile glutinous substance in the living subject, constantly renewed by the circulation. Nothing, however, demonstrates this to be the case, or that the fibres are hollow; it is much more probable that they are solid.

§ 660. The muscles are enveloped by the cellular tissue which forms membranes and sheaths for them; it is the same with regard to their bundles and the subdivisions of these bundles; only, in proportion as the parts enveloped are less voluminous, the cellular tissue forms envelops more slender and soft. The fasciculi are enveloped and united together by almost imperceptible layers of this tissue; in fact, the primitive fibres are united together in each fasciculus, by prolongations of its envelop, which, by their tenuity and softness, entirely elude observation. The cellular envelops are perceptible either by separating the bundles and the fasciculi from each other, or by cutting the muscle transversely.

Adipose tissue is likewise found surrounding the muscles in the intervals of their bundles, and sometimes even between the fasciculi.

§ 661. The blood-vessels of the muscles, well described by Albinus and Haller, and delineated by Prochaska and Mascagni, are very numerous, less so, however, in the mucous membrane. Their abundance is proportioned to the size of the muscles; nevertheless, the interior muscles are more vascular than the exterior, and among the former some in particular are very much so. The veins, as in most of the parts, possess a capacity superior to that of the arteries. They all communicate with the vessels of the tegumentary membranes, especially in the immediate neighbourhood of the muscles;

they all, after being first divided in the cellular membrane, and there presenting considerable anastomoses, penetrate at various angles the divers bundles, and are there again subdivided in order to penetrate between the fasciculi, and moreover into the intervals of the fibres, always following the cellular envelops, and continually presenting new divisions and new anastomoses. In all their course, these vessels accompany the divisions of the muscles by twigs parallel to them, and again cross the direction by other transverse twigs which surround them. Arrived at their ultimate point of division, the arteries continue their course with the veins, without our being able to ascertain how they contribute to the texture and to the nutrition of the fleshy fibres.

It is not to the blood-vessels of the muscles that the reddish colour of these organs is owing, for the interior muscles, which are very vascular, are whitish.

Lymphatic vessels are to be distinctly seen in the intervals between the greater part of the muscles, and in the thickness of some of them; as to the manner in which they arise, it is unknown: possibly they may be the continuation of the cellular tissue intermedial to the fibres.

§ 662. The nerves of the muscles are very voluminous; excepting the skin and the senses, no part is so abundantly provided with them. In general they are proportionate in number and size to the volume of the muscles; nevertheless the interior muscles have less in general than the others, and among these latter, those of the skeleton less than those of the larynx and senses. They generally accompany the blood-vessels, and particularly the arteries, and are slightly attached to them by the cellular tissue. In order to perceive them distinctly, the muscles must be mascerated until arrived at a state of putrefaction, which in effect destroys the muscles more rapidly than the nerves; they penetrate at divers points into the muscles, and there are divided in the same manner as the vessels; but they very soon elude the sight, without the possibility of being seen by any artificial means; so that nothing can be positively affirmed as to their termination. It is conjectured with some appearance of probability, that their divisions extend as far as

the primitive fibres. It would seem that before they disappear altogether, they become soft, divesting themselves of their own envelop, so that their medullary substance comes in immediate contact with the muscular fibre. Munro and Smith thought they had perceived that the nerves of the muscles have their fibres twisted in a spiral line.

According to Messrs. Prevost and Dumas,* the nerves of the muscles are perceived in the following manner in preference to any other: a bit of the muscle of beef is examined after being macerated in pure water, and in a dark place; by throwing a cone of lively light on the muscle only, we distinguish the colour of the nerve to be obviously different from that of the muscle, and it can be traced very far by means of a good lens, and a very slender scalpel; the ramifications are then seen to terminate by inserting themselves between the muscular fibres, the direction of which they cut at right angles. In order to observe this arrangement throughout the whole mass of a muscle thin enough to be transparent, the rectus abdominalis of the frog is laid on a thin plate of glass, it is examined by illuminating it by transmission by means of a weak magnifying glass and the light of a candle; the nerve and its twigs are then perceptible, and may be distinguished from the muscular fibres and their direction. In fact, the trunk of the nerve continues its course through the thickness of the muscle parallel to its length, and its branches separate from it at right angles to enter between the fasciculi and the muscular fibres; and as they are all formed on the same plan, because of the moderate thickness of the muscle, they represent a sort of comb. If the muscle be contracted, the last visible transverse fibrils of the nerve are seen to correspond exactly with the summit of the angles, or of the flexuosities of the muscle.

The nerves, though numerous and voluminous in the muscles, escape the sight long before their divisions are by any means sufficiently multiplied to admit of their being distributed to all the muscular fibres. Two hypotheses have been imagined to explain their action in all the fibres. Isenflamm and M.

* Unpublished memoir.

Carlisle suggest that the nerves, at their termination, are diffused in the cellular tissue of the muscles, and that this tissue participates of the conducting property of the nerves. Reil admits that the nerves possess a sphere of activity extended beyond their termination, and which he calls nervous atmosphere; these are suppositions which shall be examined hereafter.

§ 663. The greater number of the muscles indeed, have the extremities of their fibres attached to ligamentous tissue, through the medium of which their action is transmitted more or less distinctly. But these ligamentous parts are much more diffused in the exterior than the interior muscles.

§ 664. The colour of the muscles varies greatly: those of the invertebrate animals and those of the cold blooded vertebrated animals are white; those of birds, mammiferous animals and man are some of them reddish, of the tint generally known by the name of flesh colour; the others are of a grayish white: the shade varies very much in all; it varies also according to different circumstances, existing before or after death. The colour is removed by washing or maceration; it appears moreover the *lighter* in proportion as the muscle, the bundle or the fasciculi is minute, and on the contrary, the *deeper* in proportion as the size of the mass is greater. In thin slices, muscular substance is semi-transparent.

The consistency of the muscle greatly varies, even in the dead body, as well from the causes which have acted before or after death, and will be examined when we come to speak of their irritability. In general, the muscular fibre is soft, humid, slightly elastic, and easily torn in the cadaver.

§ 665. Muscular flesh exposed in thin slices to the action of a current of dry air, or of a stove, loses more than half of its weight, becomes brown, more transparent, and very hard. On the contrary, if it be put in cold water frequently renewed, the flesh loses its hue entirely, and assumes a straw coloured tint; maceration moreover softens and swells it.

Alcohol, diluted acids, the solution of corrosive sublimate, those of alum, common salt, and nitrate of potash, augment the consistency of the muscle, slightly contract it, favour its

separation into fibres and change its colour in various manners. Alcohol renders it pale; alum turns it brown and hardens it greatly: nitrate of potash and common salt render it slightly red, and having at first hardened it, afterwards soften it, especially the first, while it retards its decomposition. According to the observations, as yet unpublished, of Mr. Britonneau, and those of Mr. Labaraque, the solution of chlorid of calcium at a suitable degree of concentration, preserves the consistency, the flexibility and other natural qualities of muscular flesh and the other soft parts.

§ 666. Muscular substance treated with cold water, yields to it colouring matter, somewhat differing from that of the blood, some gelatin and albumen, and an extractive matter noticed by Thouvenel.

Submitted to the action of boiling water, flesh furnishes a greater portion of these same substances, and moreover some fat. The muscle thus treated, and exhausted by the prolonged action of water, there remains only some discoloured fibres, insoluble in water, easily separated, by desiccation becoming brittle, and having all the properties of fibrine. Muscular substance being calcined, leaves about one twentieth of its weight of saline matter.

It follows from these facts, observed by Thouvenel, Fourcroy, M. Thénard and others, that the muscles are principally composed of fibrine, that they also contain albumen, gelatin, extractive, osmazome of M. Thénard, phosphates of soda, ammonia and lime, and carbonate of lime.

These observations have been particularly made on ox's flesh; but as the chemical properties of the muscles present differences even in animals of a nature very similar, they are not perhaps exactly applicable to man.

§ 667. During life, the muscles enjoy an active force or property, commonly designated under the names of muscular irritability, muscular force, or myotility.

§ 668. Muscular action* has been the subject of much labour

* *See* Fr. Glisson, *anat. hepatis.* Lond. 1654.—Swammerdam, *Biblia nat.*,

and research on the part of Haller, of several physiologists anterior to him, and of a great number of his cotemporaries and of his successors.

The study of the muscular action comprehends: 1st, that of the phenomena of this action; 2d, that of its conditions; 3d, that of its principle or cause, and 4th, that of its effects.

§ 669. The *phenomena* of the muscular action which are best known are the following: the muscle in action becomes shortened, tumefied, hardened; we are uncertain whether or not its volume changes; its colour does not vary; it presents wrinkles or folds on its surface; its fibres and fasciculi are often in a tremulous or oscillating state depending on its alternate contraction and relaxation; it acquires great force and manifest elasticity: these are the phenomena of *contraction;* the most remarkable of these facts indeed, is the shortening of the muscle. When the action ceases, all these phenomena disappear, and the muscle is then in a state of relaxation.

tom. ii.—Haller, *de partibus corp. hum. irritabilibus; in comm.* Gotting. tom. ii, *et in nov. comm.* Gotting. tom. iv.—*Mémoires sur la nature sensible et irritable des parties du corps humain.* Laus. 1756-59.—Petrini, *sull 'insensib. e irritab. dissert transp.* Roma, 1754.—Fabri, *sull 'insensitiva e irrit. opulscol. raccolti.;* Bonon, 1757-59.—A. G. Weber, *de initiis ac progr. doctr. irritab., etc.* Halæ, 1783.—J. L. Gautier, (*præs. Reil.*) *de Irritabil. notione, etc.* Halæ, 1793.—*Croonian*† *lectures on muscular motion, in Philos. Trans.* 1738. 1745, 1747, 1751, 1788, 1795, 1805, 1810, 1818, &c.—J. Chr. A. Clarus, *der Krampf.* Lips. 1822.—Lucæ, *Grundlinien einer physiol. der irritabilitat des menschlichen organismus, in Mechel's Arch.* B. iii.—G. Blane, *On muscular motion;* Lond. 1788, *et in select. Dissert., etc.* Lond. 1822.—Barzelotti, *Esame di alcune moderne teorie alla causa prossima della contrazione muscolare;* Sienna, 1796, *et in Reil's Archiv.* B. vi.—H. Mayo, *Anat. and Physiol. commentaries,* No. 1. Lond. 1822.

† Dr. W. Croone, who died in 1684, left the plan of two lectures to be instituted, the one at the College of Physicians, on the nerves and brain; the other, which was to be annual, at the Royal Society of London, on the nature and laws of muscular motion. The latter is still continued, and has given rise to several excellent papers, both on the texture and action of the muscles. Several of these lectures are not consigned in the Philosophical Transactions.

Are the muscles also susceptible of *active elongation?* Numerous facts have been cited in favour of this opinion. Among them, there are some* which prove nothing in its favour; others, reported by Bichat, Autenrieth, Sprengel et Meckel, leave the question still at least undecided.

It has been also admitted that there is in the muscles a *fixed situation*, or an action in which they are neither contracted nor elongated. The same may be said of this phenomenon as of the preceding.

§ 670. The contraction or shortening being the fact best established in the muscular action, it must be examined in detail, as well as its concomitant phenomena.

The muscle augmenting in thickness at the same time that it is shortened, the simultaneous occurrence of these two phenomena, has given rise to a question that has greatly occupied the attention of physiologists, and which is not yet entirely resolved: it is to ascertain if the volume of the muscles changes at the moment of their contraction.

The experiments of Swammerdam, Glisson, Goddart and Erman, on the diminution of the size of the muscles during their contraction, does not prove decidedly that this diminution takes place. The same obtains with respect to the experiments and the reasonings of Amberger, Prochaska and Mr. Carlisle in favour of augmentation: they leave the question equally undecided. It is very probable, according to the observations and experiments of Mr. G. Blane, Barzelotti, Mr. Mayo and Messrs. Prevost and Dumas, that there is no change of volume, and this accords with the opinion of Sœmmering, Sprengel and Meckel; the shortening and swelling of the muscle mutually compensating each other.

§ 671. The shortening manifests itself by various effects. The swelling is evident to the simplest observation. The induration is sensible to the touch.

§ 672. The colour of the muscles suffers no change during the contraction. It has been thought that the contrary was

* V. Barthez, *nouv. élim. de la science de l'homme*, tome i.

† Barthez, *ibid.*

perceived on examining the heart of young animals while in action; the apparent change of colour is only owing to its transparency.

§ 673. Many physiologists have ascribed the muscular action to the accumulation of blood in the muscles, either in the interior itself, or the invervals of the fibres; others to causes analogous, all of which suppose an augmented activity of the circulation during the muscular action. Haller has already offered many objections to these hypotheses. There is no direct proof of the afflux of blood in the muscles during their action. The experiments of Barzelotti moreover prove that the contraction of the muscles of the frog, excited by galvanism, can take place after death: 1st, when the blood no longer circulates in the vessels; 2d, when the blood is even congealed, and 3d, when, in fine, the vessels are deprived of blood altogether. The question, it is true, arises as to the cadaverous contractions exerted by galvanism; but other facts prove again, that the presence of blood in the vessels of the muscles is not necessary to their contraction. Nevertheless, it is known that, when there is fluid blood in a muscle, contraction, even after death, puts the blood in motion, as if by a kind of *exposition.*

§ 674. The fibres which were straight during the state of relaxation, bend during contraction, forming very regular sinuosities. These sinuosities or folds, before perceived by numerous observers, have been carefully examined by Messrs. Prevost and Dumas, who have recognised these zigzags as being always produced in the same manner, and that the apex of the angles, which are the points of the fibre that approach each other outside of the line of contraction, are also those where the last transverse ramifications of the nerves terminate.

§ 675. During the contraction of the muscles there exists a continual fibrillar agitation* in their thickness; some of the fibres contract, while others are relaxed. It is to this cause that we must ascribe the noise that is heard when the finger

* Roger, *de perpetuâ fibr. musc. palpitatione;* Gott, 1760.—Wollaston, *Croonian Lecture, in Philos. Trans.;* Ann. 1810.

is applied to the orifice of the auricular canal, as well as that which is perceived by the application of the stethoscope on the muscle in action. This phenomenon is principally and perhaps solely rendered appreciable in a muscle where the action is kept up for some time. It has only been observed to exist, either by the help of the sight or hearing, in the exterior muscles, and in the heart.

§ 676. Certain muscles are capable of partial contraction. This is at least seen in the experiments on living animals, and in some cases of convulsion of the subcutaneous muscles. Is this peculiar to the muscles which have several nerves?

§ 677. The rapidity as well as the force of contraction are extremely great; the rapidity is very great in the action of running, in that of speaking fast, in that of playing on stringed instruments, &c. This rapidity, in some cases, may be carried to less than a *third* in point of time. The force of the muscles when in action is enormous, and is sometimes sufficient to rupture the tendons or the bones, parts of the body so capable of resisting rupture; it is always in proportion to the number of muscular fibres, each of which possesses its own force, which is a fraction of the total force. The elasticity of the contracted muscles is particularly manifest in the production of the voice.

§ 678. It is difficult to determine the extent of the contraction; it has been attempted on the principle of certain hypothetical ideas as to the form of the primitive fibres, and it has thus been estimated at one third the length of the fibre. Direct observation demonstrates that the shortening of the contracted fibre, in the exterior muscles, is the fourth of its length; Messrs. Prevost and Dumas have arrived at the same result by measuring the angles, which are formed during contraction. However this may be, the extent of the contraction is always in proportion to the length of the muscular fibres. When nothing is opposed to the contraction of the muscle, it is capable of producing a very great shortening, examples of which are seen in cases of fracture, and loss of substance in the bones and members.

§ 679. *The conditions* of muscular action are the life of the

muscle and its communication with the circulatory and nervous centres, its integral state, and the action of an exciting or stimulating influence.

Muscular action can not occur unless the circulation takes place in the muscle; should the arteries or principal veins of a part of the body be tied, its muscular action is considerably weakened. The muscles, in order to act, must also communicate through the nerves, with the nervous centre; the interruption of this communication arrests the muscular action more or less suddenly. It invariably and instantly stops the influence of the nervous centre; but the muscle remains irritable from causes that act on it, or on the nerve to which it is still attached.

§ 680. The muscle must be in its integral state; the contusion of the muscles, the inflammation of their cellular sheaths, the accumulation of fat in the intervals of the fasciculi, &c., are so many circumstances that more or less oppose the muscular action. The excessive distention of the muscular fibres is sufficient to prevent their action; this is not altogether the case with respect to their contraction. An extreme degree of heat or cold, the immediate application of opium on the muscles, and many other substances, diminish the muscular irritability in general, but have little effect, however, on galvanic susceptibility.

§ 681. To bring the muscle at all into action, it must be excited by some stimulant. The stimulants of muscular action are: 1. Volition, or the action of the will; it acts on the muscles through the medium of the nerves, but it only serves as a stimulant to certain particular muscles, which for this reason are called voluntary muscles; 2. Emotion or passion which acts by the same means, but the action of which is extended to all the muscles; 3. The irritation of the encephalon, of the spinal marrow, or of the nerves, which in the first case, also acts on all the muscles, but with more or less energy; 4. The stimulation of some determined part, of the skin or the mucous membrane, more or less remote from the muscles; 5. That of the membrane which immediately covers the muscles, as the internal membrane of the heart, the cellular sheath of the mus-

cles, the serous membrane of the abdomen, &c.; 6. Lastly, the direct irritation of the muscle itself: it remains doubtful, in this case, whether the exciting cause acts immediately on the muscular fibre, or through the medium of the nerves. What renders this last supposition the more probable, is that the irritation of a part of a muscle produces the contraction of the entire muscle itself.

§ 682. *The cause* of muscular action is, like that of all organic action, almost impossible to determine: we know the phenomena and conditions, beyond that, all is mere hypothesis. This cause has been ascribed to the action of the nerve, to that of the blood, to the reciprocal action of the nerve and the blood in the muscle; and according to the doctrines prevailing at different periods, these opinions have given birth to a great many different hypotheses, none of them have accounted for the augmentation of the power of cohesion of the muscle. It is evident that during contraction there is a momentary increase of molicular attraction between the particles of the fibre. If the plaited form assumed by the fibre be considered, as well as the connexion of the nervous filaments with their plaits, it may readily be conceived that the nervous influence must share largely in the phenomenon of contraction.

§ 683. Is irritability a power inherent in the fibrinous substance of the muscle, and does the nervous action only there take place like any other excitant causing contraction? In this hypothesis, the nerves would, in the voluntary muscles, only fulfil the function of irritating them; and with respect to the muscles which, as the heart, do not contract voluntarily, the nervous action would not manifest itself under ordinary circumstances. Or, on the other hand, has irritability its only source in the nervous system? By this hypothesis, the nerves would fulfil, with regard to the voluntary muscles, the double office of rendering them irritable and of causing them to contract; and, with regard to the involuntary muscles, the contraction of which is determined by local stimulants, it would render them only predisposed to this contraction. Or, lastly, have the muscles an inherent power, (*vis insita*) and a power borrowed from the nervous action (*vis nervea*)? It is almost

impossible to answer these questions, or to choose between these hypotheses with any reasonable motive of preference.

§ 684. *The effects* of muscular action in the living body are to produce or to prevent the movement of the solid and liquid parts, or even of the whole body, as the case may be.

The modes according to which the muscles exercise their action, may be reduced to two: 1. The two extremities of the fibres in action may remain equally stationary, as in the action of the diaphragm, the muscles of the abdomen, the buccinator, &c.; or be equally moveable, as in the sphincters, the annular fibres of the stomach, the intestines, &c.; 2. One extremity of the fibres in action is more fixed than the other, so that the more moveable one is drawn towards the other, as in the greater part of the muscles of the members; particularly in those of the fingers and toes; or else one extremity is absolutely stationary, and the other absolutely moveable, as in the muscles of the eye, the soft palate, &c.

§ 685. The actions of the muscles that naturally take place in the body, may be divided into two classes: voluntary and involuntary.

The voluntary actions are those of all the muscles that serve the purpose of the skeleton both when stationary or in motion, that contribute to the movements of the larynx, and to those of the organs of sensation. All these muscles receive their nerves directly from the spinal marrow.

The involuntary actions may be subdivided into three orders; some are produced by the stimulus acting across a thin membrane which immediately covers the muscles; such are the movements of the alimentary canal, of the bladder, of the heart, &c.; others are produced by stimuli of an analogous kind, but which are propagated by means of a connexion with many other muscles: such are the movements of deglutition, respiration, coughing, sneezing, fecal excrementation, emission of sperm, urinating, accouchement, &c. The others are the movements of emotion or passion, such as laughing, crying out, &c.

Among the actions or movements of this second class, some have been considered as semi-voluntary, or as constituting an

intermediate class of mixed movements. It is in fact extremely difficult to establish a well marked distinction between the voluntary movements, that is to say, those under the perfect control of the will, and the involuntary movements; for on the one hand, there are few functions over which the will, and above all the passions, do not exercise their empire; and on the other, many of the voluntary movements become, by assuetude, almost involuntary; such, for example, are the movements of the members which take place without consciousness, and without exercise of the will during sleep; such are those of the eyelids which take place even in opposition to the will, when a foreign body approaches the eye; the difficulty or the impossibility of moving simultaneously the superior or inferior members, or the eyes, in a direction opposed to that which they are ordinarily accustomed to, are moreover of this character. The accidental irritation of the muscles, of the nerves, or of the nervous centre, sometimes renders the contraction of the exterior muscles altogether involuntary; other affections render them immoveable in spite of the will. As to the influence of the will on the movements regarded as involuntary, it is evident in those of respiration, of vomiting, and ruminating; it even appears to be sometimes extended to the movements of the heart, to those of the uterus, the iris and the skin; it is true, that the influence of the passions on the will itself must not be forgotten.

The movements that have been regarded as mixed, are more especially those which, occurring in general unconsciously, and without the exercise of the will, may be modified by the latter; of this character are those of the diaphragm. This name is not so generally given to those which being habitually voluntary, are exercised by habit and association, without being directed by the will, as movements by which the superior members are balanced in walking.

It is to be remarked that apoplexy and the other cerebral affections generally paralyze the voluntary muscles only.

§ 686. The varied muscular movements which take place in the living body, are in general either connected with each other, in order to produce an identical action, or opposed to

each other, to produce contrary actions: in the first case, the muscles are called congeneric; in the second antagonist. Antagonism is much the most evident in the exterior muscles, as, for instance, it is seen in the flexors and extensors; it is less strongly marked in the interior or automatic muscles; nevertheless, it is not altogether foreign to them; opposition of the automatic and arbitrary muscles occurs at the natural orifices, as is perceived between the excretory muscles, which are involuntary, and the sphincter muscles which are voluntary. Antagonism every where presents this remarkable phenomenon, that the contraction of some muscles is accompanied by the relaxation of another. The congeneric or associated muscles present another important phenomenon, which is, that their contraction is simultaneous, and that, when a stimulus is confined to one only, the rest nevertheless come into action: thus when the throat, the orifice of the larynx, the anterior angle of the vesical trigon, &c., are stimulated, all the muscular powers exercised in vomiting, in coughing, or in urinating, &c., are brought into action by the law of association of the congenerous muscles, but at the same time and in conformity with the law of antagonism. In the last case the sphincter and constrictor muscles of the neck of the bladder, and of the ureter, are relaxed.

§ 687. The muscles continue, some time after death, and after circulation ceases, to be irritable and contractile by means of divers stimuli. All the muscles do not preserve their irritability during the same period; neither do they suddenly lose their susceptibility to contraction, but cease at first to be excitable by certain stimuli; the anterior state of health, the kind of death, the exterior circumstances before death, have a great influence on the duration of the muscular irritability. Galen, Harvey, and Haller, knew that the heart is in general the *ultimum moriens*. Haller had established an order of cessation of irritability in the different muscles, and also perceived several varieties in that order. Zinn, Zimmermann, Ader, Froriep, and particularly Nysten, have particularly studied this subject. The varieties perceived by Haller, depend greatly on the nature of the excitant; for instance, the heart

remains irritable much longer than any other muscle, by the application of mechanical agents, and the muscles of the skeleton, on the contrary, by galvanic irritation. Galvanic irritation acts more efficaciously by not comprehending the exterior muscles, than by comprehending them with the nerve in the galvanic circuit. The contrary occurs with the interior muscles.

The order established by Nysten, with respect to the successive extinction of irritability in the bodies of decapitated individuals, is as follows: 1st, the aortic ventricle of the heart; 2d, the large intestine, the small intestine and the stomach; 3d, the urinary bladder; 4th, the pulmonary ventricle; 5th, the œsophagus; 6th, the iris; 7th, the exterior muscles; 8th, the right auricle, and lastly, the left auricle.

Muscles or parts of muscles, separated from the living body, retain their irritability for some time. They present, in this respect, variations analogous to those which have just been indicated. Contraction under these two circumstances evidently takes place without an afflux of blood.

§ 688. When irritability is on the point of being extinct or exhausted in the muscles, irritation no longer determines any general or extensive contraction of the entire muscles, their bundles or fasciculi; but it remains limited to the points irritated, which swell by the flexuosity of which it becomes the seat. This last description of irritability which survives the nervous action, appears to me to be precisely of the same kind as that observable in the fibrine of the blood; this is in reality the *vis insita* of the muscular fibre.

§ 689. The kind of death, the previous state, and the surrounding circumstances, exert an influence on the cadaverous irritability. The state of paralyses and of hemiplegia does not prevent the muscles from being irritable in the cadaver, by galvanism. Diseases have a much greater influence on the cadaverous irritability by their progress and continuance, than by their nature; chronic diseases alter this property much more than acute ones, and among the chronic diseases, those in which nutrition is most impaired, are most fatal to muscular action. The most muscular persons are not those in whom mus-

cular irritability continues longest after death. This duration varies from one hour to twenty-four hours, or thereabout.

§ 690. Finally, after all irritability, general or local, has ceased in the body deprived of life, cadaverous stiffness ensues.(124) It is an invariable phenomenon, whatever may have been said of it by Haller and Bichat, but it varies in its intensity as well as duration. This contraction or stiffness, has its seat in the muscular system, and is independent of the nervous system; it takes place only when this system has ceased to possess any galvanic irritability. The section of the nerves, the state of hemiplegia and the oblation of the nervous centre, do not hinder it from manifesting itself. It is the last effort of muscular contractility. In cold blooded animals, in which nervous excitability continues for a long time, cadaverous stiffness occurs late and continues but a short time, whereas, in warm-blooded animals, it takes place soon after death and continues a long time; in which nervous excitability is of short duration. Cadaverous stiffness seems to be analogous to the contraction of the fibrinous coagulum of the blood, and like this, only ceases when putrefaction commences. It may be considered, when joined to the coldness that always accompanies it, as a certain sign of death. If a muscle in a state of stiffness be immersed and preserved in alcohol, that stiffness will continue for an indefinite period.

§ 693. Other moving properties have been attributed to the muscles. Galen recognised in them a tonic force, independent of life; elasticity has likewise been ascribed to them; Haller ascribed to them contractile force in general, as well as dead force; Sympson and Whytt attributed tonicity or tonic force to them; Bichat, in addition to voluntary contractility, and irritability or voluntary contractility, attributed to them insensible organic contractility, that is to say tonicity.

The muscles are extensible, they are retractile also, and this independently of their contraction by irritation. In the state of sleep and of repose the muscles furnish generally to the different parts of the body, mean attitudes depending on their proportionate length, and consequently on their tension, on their force, and on the manner, more or less efficacious, in

which this force is applied. The same thing takes place in paralysis determined artificially, by cutting all the nerves of a member. In paralysis arising from cerebral affection, and in contraction of the limbs, the attitude is sometimes different; the flexion being sometimes carried to a great extent. But here arises a doubt, which is, whether the cause of paralysis has been equally extended to all the nerves of the part; if indeed this cause does not originate in the tonic contraction of some muscles. In the dead body the muscles remain contractile, and give a determinate attitude to all parts of the body, until the cadaveric stiffness subsides.

§ 693. The muscles are possessed of sensibility, but only in a moderate degree. In the state of health they produce little more than the sense of fatigue during and after their action, when it has been prolonged. When the action has been very long continued and violent, it produces a painful sensation. The same thing occurs in case of inflammation of their tissue or of their cellular sheaths. Cabanis and Dr. Yelloly have stated cases of diseases in which the muscles were insensible.

§ 694. The circumstances which manifest a continual change of particles in muscular nutrition are not very evident; the fact is nevertheless probable: it would seem to be the globular part of the blood that furnishes the materials for it. The effects of exercise on nutrition, the augmentation and coloration of the muscles, and the opposite effect of rest too long continued, are well known. Paralysis produces an effect still more remarkable on their diminution. The quantity and quality of nourishment have a great influence on the volume as well as strength of the muscles. Certain consumptive diseases, such as phthisis, have a strong influence on muscular atrophy. We are ignorant whether, in this case, there is a diminution of volume only, or a disappearance of the fibres altogether.

§ 695. In the embryo, the muscular tissue is not distinct from the cellular tissue; they are confounded in a common gelatinous mass. At a period but little remote from the moment of conception, the action of the heart presents a considerable degree of development in the muscular tissue of that

organ. About two months after conception, the muscles of the skeleton have acquired distinct fibres; towards the fourth month they begin to execute contractions. According to Bichat, the muscles of the fœtus possess a smaller degree of irritability, or at least less galvanic susceptibility, than that of individuals who have respired. Experiments made by Meckel on some animals have offered results contradictory to those of Bichat.

During childhood the muscles continue small in volume in proportion to the nerves and adipose tissue. At this age too, the muscular flesh is not only less red, but is more gelatinous and less fibrinous than in adult age; the motions are easy, prompt and feeble.

The muscles, which are of a vermilion red in the adult, become pale, yellowish and livid in old age; contractions at this period become difficult, feeble and slow.

The irritability and action of the muscles in females, compared with those in males, present nearly the same difference as those of the adolescent compared with those of the adult: that is, a greater degree of irritability or susceptibility of movement, a weaker action and less capable of a continued action.

Between the races of mankind there exist differences in muscular power, which, according to the experiments made by Peron with the dynamometer, is in favour of Europeans, whose health and strength are the result of abundant and wholesome diet and habitual occupation, while the inhabitants of Timor, New Holland, and Van-Diemen's Land, exposed as they are to every kind of privation, have less muscular strength.

§ 696. When the muscles are exposed to view* by a wound of the skin, the aponeurosis and the cellular sheaths, and these parts, are brought together again with precision, there occurs in the solution of continuity an effusion of organizable fluid; at first slightly adherent to the muscle and afterwards establishing an organic reunion. The same thing happens when

* B. Fr. Schnell, *Præs.* Autenrieth, *de natura reunionis musculorum volneratorum.* Tubingæ, 1804.

muscles, divided crosswise, in amputation for example, are covered over again by the flaps of skin; only the agglutinating matter is from the commencement very closely attached to the truncated extremity of the muscles. When muscles are cut crosswise, and not covered by flaps of skin, there soon forms at their extremity suppurating granulations, and afterwards a cicatrice; these phenomena, and particularly the last, are more tardy when the muscles are only laterally denuded. In all these cases, at whatever period an inflamed wound is examined, whether the inflammation be adhesive or suppurative, the cellular sheaths of the muscles and of their bundles only are changed; no change whatever is perceptible in the muscular fibres themselves. It is proper to observe, however, that in this case the fibres are deprived of the greater part of their irritability.

§ 697. When a muscle is cut across, a considerable separation takes place between the edges of the division, and always greater than the wound sustained by the skin. When the edges of the external wound have been brought together, and have united, the ends of the muscle remain separated, at first filled with an organizable liquid, which afterwards becomes vascular, soft, which contracts a little and slightly diminishes the distance which existed between the ends of the muscles, and at last becomes more or less firm and resisting. This intermediate substance, when its organization is completed, has sometimes the appearance of cellular tissue, frequently that of ligamentous tissue, and sometimes that of sub-cartilaginous coriaceous tissue, but never that of muscular tissue. At some period of the formation we are now examining, it is always found that the muscular fibres and fasciculi are foreign to it, and that it is only the reunion of the cellular tissue which forms sheaths to them. A muscle which is reunited in this manner, presents a kind of aponeurotic tendinous intersection; it is a kind of digastric muscle, the two bellies of which are living and irritable, whilst the intermediate substance fulfils the functions of a tendon which more or less resists or gives way to distention. This intermediate substance is not irritable either by mechanical stimulants or gal-

vanism. However, when irritability is well manifested and the galvanic action is strong, the irritation applied to one of the parts of the reunited muscle, is propagated through the cicatrice, which however does not contract with the other part of the muscle. We are ignorant, if during life, and by the action of the will, the parts of a muscle divided across and united by a cicatrice, both contract. It is evident that the greater the separation between the muscles at the time the mediate reunion has occurred, that also the means of reunion will be longer and more extensible, and the more will the muscles have lost of their extension and power. Under the most favourable circumstances, movements at first are impossible and afterwards feeble and uncertain until the means of union have acquired their proper degree of firmness.

All that has just been advanced on the reunion of the muscles that have been cut across, is applicable to their rupture through effort.

When a transversal wound of the muscles or of the skin has remained separated and gaping, there is found throughout its extent, a layer of suppurating granulations, and afterwards a cicatrice more or less extensive, under which the two ends of the muscle remain separated.

In the latter case, as well as the former, the intermediate substance, too long and too extensible, which formed the reunion of the divided muscle, has sometimes been denuded and cut out; by afterwards bringing into contact the divided parts and retaining them in that state sufficiently long, a short and firm reunion has been obtained and motion restored to parts which had almost entirely lost it.

§ 698. The muscles are subject to variations and to malconformation; monstrous fœtus, acephalus* and others, have been seen, deprived of all the muscles or of all those appertaining to a particular member at least, these organs being replaced by infiltrated cellular tissue.

We observe more frequently the defect or absence of single muscles.

* Béclard, *Mémoires sur les fœtus acéphales.*

Supernumerary muscles, and others divided into several distinct parts, are often found; muscles united which ordinarily are separate; others, longer or shorter than is natural, which changes their attachments and modifies their functions; all these varieties are original or primitive.

The diminution or augmentation of the volume of the muscles are, on the contrary, owing generally to accidental causes. Repose and paralysis diminishes their size, exercise augments it.

Muscular ruptures* happen, either by the action of the antagonist muscles, or by another power which distends a relaxed muscle, or by the action of the ruptured muscle itself; in this last case, the rupture most commonly occurs at the union of the tendinous or aponeurotic parts with the fleshy fibres, a small number only of which are torn. In case of rupture, there occurs a separation, attended with noise and pain, and more or less extensive and deep, and an effusion of blood more or less abundant in the solution of continuity and in the surrounding cellular tissue. The interior muscles, and especially the heart, are sometimes ruptured by their contraction.

The displacement† of the muscles, admitted by Pouteau, Portal, and other pathologists, is scarcely possible, unless the enveloping aponeurosis be severed.

§ 699. The muscles present many alterations of colour, consistency, and cohesion.

In rheumatism, a gelatiniform liquid is sometimes found on the surface, in the interior, and in the thickness of the cellular sheaths.

In cases of long standing paralysis, the muscles are emaciated, white, and sometimes very fat. We have already seen above, (168) that the transformation of the muscles into fat, was rather apparent than real. It results from the paleness occasioned by the atrophy of the muscle, conjointly with the accumulation of fat between the fasciculi of fibres.

* J. Sédillot, mémoire sur la rupture musculaire, *in* Mém. et prix de la Soc. de méd. de Paris 1817.

† J. Hansbeand, *Diss. luxationis sic dictæ muscularis refutationem sistens;* Berol. 1814.

Accidental productions, either of analogous tissues or morbid tissues, are rarely observed in the muscles. Accidental bones are, however, sometimes found in them. I once found a mixed osseous and cancerous production, occupying the muscles of the calf of the leg. The leprous cysticercus, *cysticercus cellulosæ* of Rudolphi, is sometimes found in the muscles of man, and often in those of swine. Accidental production of the muscular tissue is very rare, if indeed it ever takes place. An affinity has, however, been established between the sarcoma and the muscular flesh. It is also said that accidental muscular productions have been seen in the serous membranes, in the bones, and in the ovaries: it appears that the observers have suffered themselves to be deceived by appearances.

The development of the muscular texture in the uterus, during pregnancy, and the disappearance of that texture after accouchement, is somewhat analogous to an accidental production.

§ 700. The functions of the muscles present varieties and alterations, some of which have their seat and their cause in the muscular tissue itself, and others in the nervous system. These varieties and these changes are, for the most part, different in the two species of muscles, and almost all are peculiar to the full, external, voluntary muscles, or to those of the animal functions.

SECTION II.

OF THE INTERIOR MUSCLES.

§ 701. These muscles, which are also called hollow muscles, involuntary muscles, and muscles of vegetative or organic functions, have no name appropriated to themselves, each of them bears that of the organ it concurs in forming.

§ 702. These muscles are, 1, the heart; 2, those which double the mucous membrane of the alimentary passages through-

out their extent; those which line the urinary and genital prolongation of the same membrane, form the bladder, the spermatic vesicles, and the uterus; those of the pulmonary prolongations of this membrane which form the bundles of the trachia and bronchæ. The sphincters, which are found at the orifices of the alimentary canal and the urinary and genital passages, may be regarded as intermediate to the two classes of muscles. Nearly the same is the case with respect to the texture, and more especially the functions, of the muscles of the skeleton, which are subservient to digestion, respiration, generation, and the urinary excretion. There is not, then, any very marked distinction between the two classes of muscles.

§ 703. The muscles in question are placed in the interior; some situated immediately under the internal tegument, and in particular, the heart, is situated very deeply and distant from the two surfaces, of which it is entirely independent.

The volume of these muscles is very inconsiderable when compared with that of the exterior muscles; they all form the parietes of canals and of reservoirs.

§ 704. These muscles are disposed in layers or in bundles crossing each other.

Throughout the whole extent of the alimentary canal, there are circular or annular fibres, and longitudinal fibres, each forming a distinct plane, more or less complete and thick.

In the reservoirs, as well as in the heart, the fibres are disposed in layers and bundles which cross each other obliquely, they have an arched form, the extremities of which are fixed to the sides of the aperture of the organ. The bundles of fibres in these organs cross each other, and are united in the manner of plexuses. This arrangement is less marked in the alimentary canal, where the muscular layers cross each other at right angles.

The muscular fibre of the interior muscles is of a grayish white in most of them, and red in the heart only. This fibre differs in no other respect from that of the exterior muscles. The uterus alone in this respect presents a well-marked difference, and characters entirely peculiar.

§ 705. The cellular tissue of the interior muscles is not so abundant, but is more compact than that of the other muscles. Fibrous or ligamentous tissue is only found in the heart, where it forms rings for the orifices of the ventricles, cords or tendons for the fleshy columns of these cavities, aponeurotic expansions which constitute in a great measure the tricuspid and bicuspid valves of the auriculo-ventricular orifices, and cords in the borders of the semi-lunar valves of the arterial orifices. Bichat, who only speaks of the tendinous cords of the fleshy columns, had before indicated that there exists differences between them and the tendons. In the other parts nothing is found analogous to the ligamentous tissue, except the submucus fibro-cellular tissue, to which are attached the subjacent muscular fibres.

The interior muscles appear to possess more blood-vessels than the exterior. M. Ribes, however, asserts the contrary. The greater part of the nerves of these muscles, which however are not abundant, belong to the great sympathetic; several are furnished by the pneumo-gastric, and some few by other nerves of the spinal marrow.

§ 706. The irritability of the interior muscles presents the same phenomena as that of the other muscles, except the *fibrillary* agitation, which has only been observed to exist in the heart.

The internal muscles possess less irritability than the external, depending on nervous influence.

Mechanical irritation is much more efficacious than galvanic action in determining their contractions. Galvanic irritation acts but slightly on them through the medium of the nerves. Nevertheless, the cardiac nerves and the heart being comprehended in a galvanic circle, the continued action of this agent determines movements in the organ.

The irritability or susceptibility of contraction of the interior muscles, is the more remarkable, from its being materially excited by local agents, which act on the fibre through the medium of the membrane that covers it; at other times the cause acts by sympathy: thus the titillation of the throat, the presence of a bougie in the urethra, of a suppository in the

anus, induce the action of the stomach, the bladder, and the intestines. The will has little control over the contractility of these muscles; yet the œsophagus, the rectum, the bladder, and even the stomach are not altogether independent of it; it appears even that the uterus, at least in birds, is also sometimes subject to the will. The small intestine, on the contrary, is not at all under its control; the heart is equally independent of it. And yet the case is still cited of an English captain, reported by Dr. Cheyne, and since related by all physiologists, and that of the late Dr. Bayle, reported by M. Ribes, who could at pleasure slacken or suspend the movements of the heart. But if the interior muscles are not subject to the ordinary influence of the will, the strong affections of the soul, and lively emotions of the mind, influence them in the most evident manner.

Haller, in admitting that muscular power is inherent in the muscles, and that nervous action is only the exciting cause of it, was led to admit, and most of his successors have admitted still more positively than himself, that the interior muscles are independent of the nervous action, at least in their ordinary and regular movements. The experiments of Legallois afterwards induced the admission of a directly contrary opinion. The more recent experiments of M. Cliff,* and those of M. Wilson Philip,† and the comparative observation of other animals, of monstrous embryos and fœtuses, were calculated to modify both these conclusions. Known facts demonstrate, in effect, that the interior muscles are independent of the nervous spinal marrow, in animals and monstrous fœtuses which have none, as well as in embryos which as yet have acquired none; little dependent on it in young animals in which its influence is not of long standing, and in animals of an inferior order, in which the nervous action has not a well determined centre; but are, on the contrary, dependent on that organ in the adult man; they are moreover greatly influenced by its lesions, and still more so by sudden lesions than by slow alterations.

* *Philos. trans.* Ann. 1815.

† *An exper. Inq. into the laws of the vital functions, &c.* Lond. 1818.

§ 707. When the interior muscles contract, they sometimes draw into simultaneous and associated action all the exterior muscles which can contribute to the accomplishment of their function: thus in coughing, sneezing, vomiting, defecation, accouchement, &c., a number more or less considerable of muscles of the skeleton act by association, with interior muscles.

The interior muscles have no real antagonists like the exterior muscles, all their fibres tending to one sole and common end, the diminution of capacity of the cavity which they form. However, we may consider as such, 1st, the foreign substances that keep asunder the parietes of the organs formed by these muscles; 2d, the various parts of a particular hollow organ: for example, the auricles with relation to the ventricles; the body of the uterus, and that of the bladder with respect to the neck or orifice of these organs; 3d, the two muscular layers in the alimentary canal in the peristaltic motion; the contraction of the longitudinal fibres determining, by pushing forward the fæces, the extension of the annular fibres. Now, there happens in this precisely what takes place in all antagonism: the contraction of one muscle coincides with the relaxation of its antagonist, and vice versa; 4th, finally, the interior muscles find antagonists in the exterior muscles. These muscles have no determined fixed point: those which are annular, contract on themselves; those which are longitudinal, however, have this point in the orifices of the alimentary canal; those of the reservoirs, as the bladder and uterus, as well as those of the heart, have also a fixed point, better determined, in the orifice of these organs.

SECTION III.

OF THE EXTERIOR MUSCLES.

§ 708. These muscles are also called voluntary muscles, muscles of animal functions, of animal life, muscles properly so called. It is these that constitute the greater part of the mass of the body.

§ 709. They are very numerous; there are from three to four hundred of them, but this number has been variously stated. Some regarding as several muscles what others have represented as bundles of an individual muscle.

§ 710. Each muscle has its proper name, but this nomenclature has greatly varied. There is scarcely a single muscle which has not received more than one name, some have received as many as a dozen.

The denomination of the muscles has been derived from several considerations: numerical order has been applied to them, thus when several muscles belong to the same part, the same region, or same action, &c.; they have been distinguished by the names of numbers, as the radial, the adductor, the interosseous muscles, have been distinguished by first, second, &c. Before James Sylvius, almost all the muscles were thus distinguished by the name of numbers. Some have adopted as surnames, their anterior, posterior, superior, inferior, superficial, deep-seated, &c., situation, or they have been distinguished by the name of the part they move, or the region they occupy, as the palpebral, occular, labial, pectoral, dorsal, abdominal, crural muscles, &c. Others are distinguished, according to their extent, or their volume, by the epithets great, small, mean, slender, vast, wide, long, short, &c. Others have been named rhomboidal, square, triangular, scalenus, &c., in conformity with the figure it was imagined they possessed; or else they have been called splenius, by being compared with the spleen, or a compress, solearis because of their resemblance to the fish called a sole, or to the sole of a shoe. Certain muscles have been named with reference to their direction, right, oblique, transversal, spiral; after their texture and their composition, they have been named biceps, triceps, complexus semi-tendinosus, perforans, perforatus, &c. Other muscles have been denominated according to their insertions, either from one of them only, as the pterygoidi, peronei, zygomatici, &c.; or from two, as the stylo-hyoideus, sterno-hyoideus; or from a greater number, as the sterno-cleido-mastoideus. Others again have been named according to their use, flexors, extensors, elevators, abductors, depressors, pronatores, supinatores, &c.; finally,

even these are not all the considerations on which the nomenclature of the muscles is based.

Scarcely any of these considerations are absolutely useless to the knowledge of the functions of the muscles; nevertheless, the most useful are, without doubt, the movement itself, the insertions, the region occupied by the muscle, its direction, &c. It would matter but little how numerous these bases were, provided they always furnished names that were proper, distinct and short, even though not very significative; but almost all the names of the muscles are names composed of several of the circumstances indicated. Thus we find in the muscular nomenclature, the names obliquus externus abdominis, rectus anticus capitis longus, radialis externus primus, rectus femoris anticus, interosseus dorsalis manus primus, &c. This inconvenience, joined to that resulting from the multitude of different names given by various anatomists to the same muscle, induced M. Chaussier* to propose a reform in anatomical language, and especially in that of myology. This reform in the names of the muscles consisted in giving to each of them a name which expresses solely and constantly the two opposite points of attachment, designated commonly under the names of origin and of insertion; but the able author of this project found it impossible to give names which were not at the same time, a pretty large number of them at least, composed of some others of the circumstances indicated above. M. Dumas† endeavoured to modify the nomenclature of M. Chaussier by indicating in his names all the points of attachment of the muscles. M. Duméril,‡ also engaged in the reform of the anatomical language, by taking for the root of this language the Greek or Latin names of the bones and of the viscera, and by merely varying the termination of these names for the various other organs and for the regions. The termination of the muscles was *ien ;* thus the name *occipito frontien,*

* *Exposition sommaire des muscles du corps humain.* Dijon, 1789.—*Tableau des muscles de l'homme.* Paris, 1797.

† *Système méthodique de nomenclature et de classification des muscles du corps humain, etc.* Montpillier, 1797, in 4to.

‡ *Magasin Encyclopédique.*

without joining to it the word muscle, designates in this nomenclature, the *occipito frontalis.* Vicq. d'Azyr had equally directed his views to the necessity of reforming the anatomical language; he did not execute his project. Doctor Barclay also engaged in this object, and directed his special attention to giving proper and precise names to the different regions of the body. M. Schréger* has collected together most of the anatomical names employed up to his time, in a voluminous synonymy, where is found almost as many names to some organs, as there are treatises on anatomy. The fear of contributing to the confusion, which is augmented almost every time that a new treaty makes its appearance, ought to induce the anatomists to make use of names already in use, in choosing from among them those that are best known, the most simple and the most significant.

§ 711. According to their situation and their destination to move any particular part, the exterior muscles are distinguished by those of the skeleton and the bones, by those of the larynx, and by those of the organs of the senses and the skin; several exterior muscles belong also to the orifices of the digestive, respiratory, genital and urinary passages, and are there insensibly confounded with the interior muscles.

The muscles of the skeleton are situated in the trunk and in the members: in the members they form considerable masses, and are elongated; in the trunk they are broad, numerous in the back and the abdomen, less so in the thorax, and still less so about the cranium.

§ 712. The muscles vary greatly in volume, some are great or voluminous, others are moderate in size, others small, and others again very small.

§ 713. All the muscles are in pairs, except the diaphragm, the sphincters of the mouth and anus, the arythenoidæus, and often the levator uvulæ; all, except the diaphragm, are symmetrical, or similar on both sides, with the slight difference ordinarily observable in the volume of the two lateral sides of the body.

* *Synonymia anatomica, auct.* Chr. H. Th. Schreger. Furthii, 1803, in 8vo. 380 pages.

According to their form the muscles are moreover distinguished by the terms broad, long and short.

The broad muscles belong to the trunk; some of them extend from the trunk to the members, and are then elongated in this last part of their extent.

The long muscles appertain to the members, and are in general disposed in layers, the most exterior being the longest and the straightest, the more profound being much shorter and more oblique: a disposition important to be known in the practice of amputations, since the muscles, unequal in length, must contract unequally.

The short muscles are met with in the trunk and in the members, near the articulations.

§ 714. The direction of the muscles is that of a line extended, passing through their centre, from one extremity to the other; it is often very different from that of its fibres, and this last is the most important circumstance. When all the fibres are straight and parallel to each other, the power of the muscle, which is equal to the sum of the power of all the fibres, operates in a manner parallel to the direction of these fibres. But if the fibres are oblique with respect to each other, the intensity and the direction of the power will be different.

§ 715. In general there is perceived in each muscle a body or belly, and two extremities, the one of origin, the other of insertion. The body is the fleshy part, the extremities are ordinarily tendinous: the extremities are also frequently distinguished into point of origin, of adhesion or stationary point, and in moveable point or of insertion; but many of the muscles will not accommodate themselves to this description. Those to which it would best apply are certain muscles of the members, which are elongated, swelled in the middle, because of the disposition of their fleshy fibres: formed of a short tendon at their superior extremity, generally the most fixed, and of a long tendon at the other extremity, generally the most moveable. But in these muscles, the movement may be divided between the two points, and sometimes may even be entirely executed by the point most elevated.

§ 716. Certain muscles form one sole fleshy body between the two attachments; others, on the contrary, are formed of very distinct bundles, which might be taken for so many muscles; such, in particular, are the masseter, the deltoid, the subscapulary, the *glutæus maximus*, &c.

§ 717. There are muscles which in their whole extent remain simple and distinct, and others which are divided into several parts, or confounded with others at one of their extremities: thus, some muscles, simple at their insertion, are separated, at their origin, into two or three parts: such are the biceps and the triceps; such are also the sterno-mastoideus and the pectoralis major, which for this reason some authors have considered as composed of two muscles each; thus the common extensor and flexor muscles of the fingers and toes, though simple at their origin, are divided at their insertion into several parts. The serrati transversi and other muscles which are attached to the ribs by digitations, are also nearly in the same state. The muscles which have a common origin may be compared to those of this description, as the muscles that are attached to the ischium, as well as those with a common insertion, as the latissimus dorsi and the teres major.

§ 718. There are again muscles the composition of which is different: such are several of the spinal or vertebral muscles, and particularly the transversalis spinæ, the longissimus dorsi, and sacro lumbalis; they each result from many muscular bundles, distinct at the extremities and confounded at the centre, in such a manner that each portion of muscle, though single at one extremity, terminates at the other with two parts; and reciprocally each of the latter is attached to a double portion of the opposite extremity: these muscular bundles succeeding each other, and uniting with each other laterally, there results from it a very long muscle, composed of short bundles, distinct at their extremities, and united laterally in their mean part. Each bundle being closely united with the two bundles, can not contract without the latter entering into action at the same time, so that the movement is always communicated at once to several vertebræ or ribs: a disposition altogether in

conformity with that of the bones, which are always to be moved, several of them simultaneously.

§ 719. The muscles of the skeleton, and these are the most numerous, have their two extremities attached to the periosteum and to the surface of the bones by tendons or aponeuroses. The muscles of the larynx are attached in the same manner, to the cartilages and perichondrium. The muscles which extend from the skeleton to the organs of sense, and are inserted into cartilages, are besides provided with tendons at both extremities; those which are attached to the teguments are, on the contrary, destitute of tendons at their insertion in the dermis.

Besides the tendons and aponeuroses of attachment which are found at the extremities of most of the muscles, some of them also present tendons or aponeuroses of intersection, which occupy some point of their extent, and divide them into several fleshy bodies. Of this description are the maxillar digastric and cervical digastric muscles, which are divided, by tendons, into two very distinct bodies; such are also the sterno-hyoideus, scapulo-hyoideus, the rectus abdominis, &c. the fleshy body of which is divided by aponeuroses.

§ 720. In a great many of the muscles the fibres are straight, and obviously parallel from one end to the other. In several muscles, the fleshy fibres, all parallel, extend obliquely between two aponeurotic tendons expanded on two opposite faces of the fleshy body; such is the cruralis anticus. It was muscles of this description, without doubt, that induced Gassendi to compare the muscles generally to a tackle of pullies. Other muscles are radiated, as the great pectoralis major, and the latissimus dorsi, the fibres of which, while spread at their origin, are collected into a thick bundle towards their insertion; as the glutæus medius, and glutæus minimus, whose fibres terminate successively on an aponeurotic expansion. In others, the fibres are extended thus obliquely from their origin from a bone to the side of a tendon: these muscles are called semi-pennate; of this description are the peronæ. Others are pennated, the fibres passing obliquely on the two sides of a tendon; in some others, very analogous to these

last, the fibres form two planes, which are inserted on the two faces of a middle aponeurosis; such as the temporal muscle. Other muscles are still more compound, as the deltoid, the masseter, &c. which result from the union of several penniform bundles.

§ 721. The texture of the exterior muscles always results from bundles more or less distinct, which generally terminate at both ends on tendinous tissue; these bundles are composed of visible fasciculi or fibres, themselves resulting from microscopic elementary fibres. The cellular tissue and the adipose tissue form for them envelopes and partitions the more distinct in proportion as the bundles are themselves distinct and voluminous. The nerves of these muscles are very abundant, especially in those of the organs of sense, and almost all come from the spinal marrow; few are derived from the grand sympathetic, and these last are never alone.

§ 722. Besides these parts so essential to the muscles, these organs have dependences: these are the *fasciæ* (519,) or enveloping aponeuroses which surround the muscles, maintain them in their place, and furnish them with partitions by which they are separated, as well as points of attachment; it is also the sheaths and rings that enclose the tendons and prevent their being displaced, and the synovial membranes that facilitate their sliding.

§ 723. The muscles are divided, with reference to the motions which they produce, into congenerous and antagonist muscles, according as they concur in the same movements, or produce opposite ones. The motions which take place in the human body, and which are produced by the muscles, are movements of flexion and of extension, of lateral inclination, of rotation in two opposite directions, which in the forearm is distinguished by the terms pronation and supination, of elevation and depression, of adduction, abduction, and deduction, of dilation and constriction, of protraction and retraction, &c. From these motions the muscles are called flexors, extensors, pronators, supinators, elevators, &c.

The antagonist muscles present some differences: in almost all parts of the body, the muscles destined to effect a motion,

are stronger than those which produce the opposite motion. Those of the two sides of the body which produce the lateral inclination, and the rotation round the axis of the body, present only the slight difference which is generally observable between the two sides of the body. The others present much more important differences. Borelli thought that the flexors were shorter than the extensors, and that contracting with an equal force, they necessarily draw the bones in flexion. Richerand also thinks that the difference is in favour of the former; Meckel has adopted this opinion: these two physiologists are of opinion that this difference is established on the observation of the bent attitude that is assumed by every part of the body in a state of repose, and that its cause exists in the force and length of the muscles, in the volume of their nerves, and in the more favourable disposition of the flexors, relatively to the centre of motion, and to the direction of the bones.

Ritter has added to these differences that the flexors contract when the positive pole of the galvanic pile communicates with the muscular extremity of the nerve, and the negative pole with the central extremity; and that the contrary obtains with the extensor muscles. This difference, doubtless, is a mere difference of galvanic susceptibility; a susceptibility sufficiently powerful in the strongest muscles, to cause them to contract under the least favourable circumstance of the galvanic action.

Roulin* thinks with Borelli, that the principal cause of antagonism between the flexors and extensors depends on their respective length, and consequently on their tension.

This question perhaps merits being considered in a more general manner; the predominance must be sought in the length and in the volume of the muscles, and more properly in the number of fleshy fibres that enter into their composition; it must also be sought in the disposition of the muscles relatively to the levers on which they act; it is necessary to observe what the attitude is that the parts take in their most ordinary action, and that which they take in repose, during

* *See Recherches sur les mouvemens et les attitudes de l'homme, dans le journal de physiologie,* Vol. I. et II.

sleep, and in a state of paralyses; regard must also be had to that which they take in general tonic spasm or in tetanus: now, in having regard to these various considerations, it would seem that the extensors are the preponderating muscles in the trunk; in the jaw, the elevators; in the superior members generally, the flexors; in the forearm, the pronators; in the inferior members generally, the extensors; and in the feet, the adductors.

§ 724. There are in the organization several circumstances* unfavourable to the action of the muscles, and which diminish their power of contraction or effective force to an efficacious force, i. e. to a much less considerable result. These circumstances, well ascertained since Borelli, are, 1st, the equal division of muscular effort between its two attachments, whilst one point alone in general is to be moved; 2d, the unfavourable lever, that of the third kind, by which a great part of the power is lost; 3d, the oblique insertion of the muscles on the bones, and of the fleshy fibres on the tendons; 4th, the resistance of the antagonist muscles; 5th, the friction of the tendons and that of the articulations.

There are also in the organization, circumstances which, by favouring muscular action, diminishes the influence of the former: of this description are the change of the angle which the muscles and the bone form, by means of certain anatomical dispositions, as the volume of the articular extremities of the bones, the existence of the apophyses at the place where the muscles are attached, that of the sesamoid bones, &c. Such is also the diminution of friction by the synovia, &c.

Finally, the animal mechanism presents the same perfection as that which is every where to be admired in nature. What the muscle loses in force, motion gains in extent and rapidity, by the employment of the lever of the third kind, and by the obliquity of insertion. On the other hand, the obliquity of the muscular fibres upon the tendons, by diminishing the extent of motion, and even the force of the muscle, permits, under a small volume, the union of a very great number of fibres,

* J. Alph. Borelli, *de motu animalium, opus posthumum.*

which compensates, and much more than compensates, the loss of power; without mentioning the form and freedom of the limbs, which could not take place with any other insertion, or any other direction of the muscles with relation to the bones.

§ 725. The muscle is the seat and the immediate organ of contraction, just as the teguments and the organs of sense, which form part of them, are the seat of impression. But just as sensation takes place only, in so far as the impression is propagated by the nerves to the nervous centre, so is it from the nervous centre that volition is propagated, by the nerves, to the muscle, for setting it in motion. In both cases, there is, moreover, something that is entirely incomprehensible; this is, the manner in which the being, the *self*, (*moi*) acquires the knowledge of the sensation, and also the manner in which it determines the volition. This is not the proper place for examining the yet unsolved question of the reciprocal action of the organism and the *self* (*moi*).

Be this as it may, the volition proceeds from the nervous centre, is propagated by the nerves, and self induces the contraction of the external muscles. If the nerve be cut or interrupted by a tight ligature, &c. the muscle, still irritable, no longer contracts voluntarily. In the following chapter will be seen what is the precise, or, at least, probable, seat, in the nervous system, of the organic principle of the voluntary motions.

§ 726. The effects of the contraction of the exterior muscles are to determine the attitudes and motions of the body, by acting upon the skeleton; to move the skin and organs of sense; to produce the voice, speech, and gesture; and, lastly, to subserve, in a more or less necessary, but always auxiliary, manner, the vegetative functions.

§ 727. It has already been seen that the straight muscles, in contracting, draw one of their extremities, or both, nearer to the centre, according as one of the points of attachment only is moveable, or as they are both so; and that the circular muscles, in contracting, narrow the orifices or canals which they form. The curved muscles become straight when they con-

tract, if their attachments are fixed; and, in tending to become so, they diminish the cavities of which they form the walls; as is the case with the abdominal muscles and diaphragm with respect to the abdomen; and they enlarge the cavity to which they correspond by their convex surface; as the diaphragm does with respect to the thorax. The reflected muscles, and they are very numerous, tend, like the curved muscles, to become straight during their contraction; but if any insurmountable obstacle comes in the way, the motion, the direction of which is changed, is transmitted to the one or the other extremity, or to both, according to their mobility.

§ 728. When one of the parts to which a muscle is attached, is immoveable, the other capable of being moved, it draws the latter towards the former; as is the case with the muscles which extend from the bones to the soft parts, &c. When one of the two parts has little mobility, and the other is very mobile, as the trunk with reference to the limbs, the central extremity of the limbs with reference to the peripheric extremity, &c. the latter is in general the only one that moves. But it is to be observed, then, in this case, that the fixed point, and the moveable point of the muscles may change. Thus, in the most ordinary motions of the arm, the muscles which move that part have their fixed point in the trunk, and their moveable point in the limb. On the contrary, in the action of climbing up a tree, the fixed point, at the moment when the trunk rises towards the arm which was previously fixed, is in the arm, and the moveable point in the trunk. So also in the action of going up a ladder, when the leg is carried forwards and upwards, the fixed point is in the trunk. When afterwards the trunk rises towards the leg whose foot is stationary and firm, the fixed point is in the leg, and the moveable points of the muscles are in the thigh and trunk.

When the two parts to which the muscles are attached are nearly equally mobile, contraction tends to move them about equally. Thus when one is lying upon a horizontal plane, the contraction of the anterior muscles of the trunk tends nearly equally to bend the head upon the neck, and the pelvis upon the loins.

In this case and in the preceding, which are of extremely frequent occurrence in the animal mechanism,* the part which is to serve as a fixed point is retained by the contraction of other muscles which render it motionless. The motions apparently the most simple almost always require the simultaneous action of a greater number of other muscles than those which are destined to produce them immediately.

§ 729. It is in efforts especially that we observe these muscular synergies.

An effort,† *nisus*, is any muscular action of extraordinary intensity, destined to surmount an external resistance, or to perform a laborious function, whether accidentally or naturally. Thus, the action of raising or carrying a heavy body, parturition, difficulty of passing the urine, &c. require efforts before they can be executed.

In every effort, there is an extraordinary nervous influx upon the muscles. Sometimes this influx is voluntary, sometimes involuntary. In the latter case, it is irresistibly determined by the connexion already remarked between the involuntary internal muscles, and their external congenerous muscles. In every effort, also, a great number of muscles, sometimes the whole apparatus of motion is in action. Lastly, in every effort, the lungs are first filled with air by an inspiration, the glottis is closed or simply narrowed, the muscles of expiration are contracted, and the walls of the thorax are thus rendered immoveable, in order to present fixed points of attachment to the muscles of the abdomen and limbs.

The effects of efforts are to retard or prevent the entrance of the venous blood into the thoracic trunks, whence its reflux and its stasis in the veins of the neck, the head, the abdomen, and even the limbs; to compress the thoracic and abdo-

* Winslow, *Mém. de l'Acad. des Sc.*, 1719-23-26-29-30-39-40, &c.

† Js. Bourdon, *Recherches sur le mécanisme de la respiration et de la circulation du sang.* Paris, 1820.—J. Cloquet, *De l'influence des efforts sur les organes renfermés dans la cavité thorachique.* Paris, 1820.—Magendie, *De l'influence des mouvemens de la poitrine, et des efforts, sur la circulation du sang.* Journal de Physiologie, vol. i.

minal viscera, and even sometimes to produce their expulsion, especially that of the latter, through an opening in the walls. Efforts occasionally even go so far as to produce rupture of the muscles, tendons or bones, and to cause ruptures of the blood-vessels, hemorrhages and effusions of blood.

§ 730. The muscles which pass over several joints may move them all. Thus the flexors of the fingers, after having bent the third and second phalanges on the first, bend the latter on the metacarpus, and the hand on the fore-arm. One of the two even contributes to pronation. It is the same in the foot, where the common extensor of the toes bends the foot upon the leg, and where even the same disposition occurs. These muscles, which pass over several joints, have also other uses. They are auxiliaries or supplementary parts to shorter muscles, extending only to the two bones united by an articulation. Thus, the biceps, semi-tendinosus and semi-membranosus of the thigh, which pass over two articulations bending in opposite directions, may assist or become the substitute in their functions, of the extensor muscles of the pelvis upon the thigh, and of the flexors of the thigh upon the leg. The muscles of this kind, which are so numerous in the limbs, especially the inferior ones, and which equally exist in the direction of extension and in that of flexion, appear also to be intended for the purpose of rendering the act of standing secure, by applying the articular surfaces against each other, and preventing motion in all directions.

§ 731. Muscular motion is simple when it is impressed by a single muscle or by several muscles which act in the same direction. It is compound, when it is produced by several muscles which act in different directions. Simple motion commonly takes place in the direction of the muscle itself or of the muscles which produce it. Thus the flexors of the fingers bring them in their proper direction. In other cases, the muscle being reflected, the direction of the motion is determined by that of the portion of the muscle which extends from the place where it changes its direction to the mobile part. Thus the motion induced by the obliquus occuli longus, by the circumflexus muscle of the palate, the lateral peronæi, &c., has a

direction determined by that of the last portion of these muscles. The direction of the motion is frequently in a great measure determined by that of the articulations of the bones. Thus the bones articulated by ginglymus and by rotatory articulation, although most of them have oblique muscles, move in only two opposite directions. Thus, on the other hand, the same muscle, the biceps flexor cubiti, without changing its direction, produces by its contraction the supination and flexion of the fore-arm. Thus also, the pyramidales, gemelli, &c., which are rotators of the thigh outwards, when it is extended, become abductors when it is bent.

§ 732. In many cases the muscular motions are compound; several muscles contracting simultaneously, communicate to a moveable part a motion different from that which results from the contraction of each of them in particular. Thus, if the rectus superior and rectus externus of the eye contract together and with equal force, the eye obeying these different forces, the pupil will be directed upwards and outwards. Thus, if the pectoralis major, which carries the arm inwards and forwards, contracts at the same time with the latissimus dorsi, which carries it inwards and backwards, the arm will be carried, by a compound motion, directly inwards. The motions of the shoulder are always compound. Many other parts are often so also; and were it not so, the motions, which are so varied, would be extremely limited.

§ 733. The motions of the voluntary muscles are in fact most commonly combined. In this respect, the muscular actions may be distinguished into isolated motions, resulting from a single muscle in contraction; into associated or combined motions, resulting from the action of several associated muscles, whether congenerous or antagonist, to produce determinate motions, as those of flexion, extension, &c.; into coordinate motions, as those which by their association produce standing, locomotion, &c.; lastly, actions of the will, or muscular actions directed by volition. These variations in muscular action depend upon the nervous influence, according as it is voluntary, and according as, without the influence of the will, it is determined by irritation of the nervous centre, by

that of the plexus of a limb, or only by that of an isolated nerve.

§ 734. The contraction of the external muscles, through causes which act upon the muscular tissue, or upon the nerves, or upon the nervous centre, sometimes becomes feeble and uncertain (in trembling;) impossible (in paralysis;) permanent (in tonic spasm or contraction, tetanus;) involuntary and irregular (in convulsions, clonic spasm, or contraction.)

CHAPTER X.

OF THE NERVOUS SYSTEM.

§ 735. The Nervous System, *Systema nerveum*, comprehends cords (nerves,) enlargements (ganglia,) and a central mass (the brain in general,) formed of a white and grayish substance, which, during life, keeps up the irritability, are the conductors and receptacle of the sensations, the point of departure and the conductors of volition; in a word, the organs of innervation.

The nervous centre is moreover the *organ*, or in other words the material instrument of *intellect*.

§ 736. The Asclepiades were not acquainted with either the nerves or the ganglia. One may easily be convinced, on reading the works of Hippocrates and Aristotle, that they have confounded under the name Νεύρον, ligaments, tendons, nerves, and even the vessels. Praxagoras appears to have been the first who had any correct idea of difference among the white organs; but having placed the origin of the nerves at the termination of the arteries, he gave rise to an opinion respecting the hollow structure of the nerves, which has been continued up to the present time. Herophilus and Erasistratus knew the connexion of the nerves with the brain, but they continued to give the same name to the tendons and ligaments. Galen unraveled the confusion which still prevailed in his time with regard to this subject, by giving names to the ligaments and tendons. By perceiving that the nerves are medullary in their interior, and membranous at the exterior, he clearly determined their connection with the spinal marrow and brain. He remarked, in opposition to an opinion that had existed previously to him, that the spinal marrow is subordinate to the

brain, which is therefore the nervous centre. He attempted to establish a distinction between the nerves of feeling and those of motion, and first described and named the nervous ganglia. He had also made considerable progress in the knowledge of the nerves in particular. The anatomists of the Italian school having found neurology much in the state to which Galen had brought it, greatly improved its condition. G. Bartholin reproduced the opinion of Praxagoras and some others of the ancients, that the spinal marrow is the centre of the nervous system, and that the brain is only a continuation of it. From this period, the anatomy of the nervous system, whether in animals, or in the human species, has been continually enriched by new facts.

§ 737. The most simple animals have no distinct nervous system (28.)

The first in which it begins to make its appearance are the radiated animals, and in particular the asteriæ or sea-stars, in which it consists of soft threads and small enlargements disposed around the mouth, both white and destitute of cineritious matter.

In all the other invertebrate animals, the nervous system consists of two more or less approximated cords, brought together into a greater or less number of knots or ganglia, improperly called spinal marrow in the articulata, always united around the œsophagus or above the mouth by a nervous ring at least, and often by a ganglion, of which the volume is proportionate to the greater or less degree of complexity of the head, and which, in the mollusca, receives the name of brain.

In all these animals, the two teguments and their muscles, the organs of the vegetative functions and those of the animal functions, receive similar nerves.

However, there already occurs in the nervous ganglion of the cephalopoda, (50) an evident indication of a nervous centre peculiar to the organs of sensation and motion.

§ 738. In the vertebrate animals,* the nervous system con-

* See M. Tiedemann's excellent work: *Anatomie und Bildungsgeschichte des gehirns*, &c. Nürnberg, 1816; translated into French by M. Jourdan: *Anatomie du cerveau, contenant l'histoire de son developpement dans le fœtus,*

sists of a central mass peculiar to that class, and composed of a longitudinal cord, the spinal marrow, in which the ganglion form is no longer apparent, and whose upper or cranial extremity, divided into the pair of cords, presents enlargements and developments, which together form the encephalon. These parts, viewed successively from behind forwards, are the cerebellum, the tubercula quadrigemina, the cerebrum, properly so called, and the olfactory lobes. The spinal marrow gives attachment to a number of pairs of nerves corresponding to that of the vertebræ. Each of these nerves is furnished with a ganglion near its central extremity. The cranial portion of the spinal marrow (the medulla oblongata) furnishes nerves to the organs of sense and the other organs of the face, and to those of digestion and respiration. Moreover, there exists on each side, before the vertebral column, a knotted cord (the great sympathetic nerve) and nervous ganglia and cords for the heart and alimentary canal, a particular nervous system, which alone, or joined to the pneumo-gastric nerve, resembles in its distribution the first appearances of this system in the animal kingdom.

§ 739. The spinal marrow, which is hollow in the oviparous animals, becomes full in the mammifera. In the former it occupies the whole length of the vertebral canal; in the mammifera it extends into the sacrum. Its volume is so much the greater compared with that of the brain, or the latter is so much the smaller compared with the spinal marrow, as we examine the animal series farther removed from the adult man to fishes. It is cylindrical, with slight bulgings at the places where the nerves of the limbs are attached to it. Its cranial portion also presents enlargements in proportion to the nerves there inserted.

The cerebellum, which is formed by the posterior or restiform cords of the spinal marrow, expanded, reflected and united above the fourth ventricle, is very simple in the osseous fishes, in many of the cartilaginous fishes, and in the great-

avec une exposition comparative de sa structure dans les animaux. Paris, 1823.—Desmoulins; *Exposition succincte du développement et des fonctions du système cérébro-spinal.*

er number of reptiles. In the others, and especially in birds, it is more complex. In them there are already perceived laminæ and the commencement of lateral hemispheres; but in no oviparous animal are there yet seen the prolongations destined to form the annular protuberance, or that protuberance itself. In all the mammifera we find the lamellated structure of the cerebellum, lateral hemispheres, a ciliary body in the peduncles, and a protuberance. These parts are the more developed the higher we rise in the class of mammifera towards man. The prolongations of the cerebellum at the tubercula quadrigemina also exist in all the mammifera. The ventricle of the cerebellum is common to the four classes of vertebrate animals.

In some fishes there are observed encephalic lobes posterior to the cerebellum. Such are those which correspond to the origin of the nerves of the electric apparatus of the torpedo.

The corpara quadrigemina, which are formed by the development of the lateral or olivary cords of the spinal marrow, appear to exist in all the vertebrate animals, although there has been much diversity of opinion with respect to their determination. In all they are the principal point of origin of the optic nerves. In all they form, by their union in the middle line, the upper wall of a cavity situated between the ventricle of the cerebellum and the third ventricle. They are so much the larger in proportion to the encephalon in general, the more simple it is. They are bigeminous only in the ovipara, and are quadrigeminous only in the mammifera. The anterior pair is larger than the posterior in the ruminantia, solipeda and rodentia. The reverse takes place in the carnivora. The two pairs are about equal in the quadrumana and in man.

The brain, properly so called, which results from the expansion of the anterior or pyramidal cords of the spinal marrow, which cross each other in all the mammifera and in the birds of prey only, and not in the other animals, and are enlarged by additional fibres from the optic thalami and the corpora striata, presents many differences in its volume and complication, which are in general proportionate to the volume of these thala-

mi and these corpora. The cartilaginous fishes have no brain. (Desmoulins.) In the osseous fishes it is formed by the optic thalamus alone, which is solid. (Desmoulins.) In reptiles and birds, it is formed by the same body, which is hollow, and bears some resemblance to the hemispheres of the mammifera; but these hemispheres do not cover the tubercula quadrigemina, and have as yet neither lobes, nor circumvolutions, nor corpus callosum. The brain of the mammifera, which is formed by a recurved medullary membrane, whose fibres come from the corpora pyramidalia, optic thalami and corpora striata, gradually approaches to that of man, presenting various degrees of organization. The rodentia and cheiroptera occupy the lowest rank in this respect. Their hemispheres do not entirely cover the tubercula. They have only a superficial fissura sylvii, a few slight grooves, and no circumvolutions. In the carnivora, the ruminantia, the hog and the horse, the hemispheres, which are much more voluminous and prominent, cover a part of the cerebellum. They have circumvolutions and anfractuosities, but are still destitute of posterior lobes. In the quadrumana, the hemispheres cover the cerebellum, but the posterior lobe is still destitute of circumvolutions.

The corpus callosum, which is formed by the reflection towards the median line of the fibres of the peduncles spread out in the hemispheres, do not exist in the ovipara. In the mammifera its extent is proportionate to that of the hemispheres. It is accordingly very small in the rodentia.

The lateral ventricles, which are formed by the replication of the nervous membrane of the hemispheres, are proportionate to the extent of the latter.

The fornix does not exist in fishes. We find the first traces of its pillars in reptiles, and still more distinctly in birds. In all the mammifera the pillars are united to form the fornix. In them there occur, moreover, the septum lucidum and its ventricle. These parts are proportionate to the extent of the hemispheres.

The cornu Ammonis exists only in the brain of the mammifera. The unciform eminence exists in none of the animals, excepting perhaps the quadrumana.

The pituitary gland exists in all animals. It is very large compared with the encephalon in all the inferior classes. The pineal gland appears to be wanting in the class of fishes.

The olfactory lobes terminate the encephalon anteriorly. According to M. Desmoulins they form what is called the brain in the cartilaginous fishes. They equal the brain in size in many osseous fishes and reptiles. They are very small in birds, greatly developed and hollow in many mammifera, and rudimentary in the human species.

The principal differences which the nervous centre presents in man, are, therefore, the volume of the cerebellum and cerebrum, compared with the spinal marrow, the tubercles and the olfactory lobes; the size of the lateral lobes of the cerebellum compared with the middle lobe; that of the cerebral hemispheres, and their posterior prolongation: the existence of its posterior lobe and its appendages; the thickness of the nervous membrane which forms the hemispheres, the size of its central medullary mass, the number and depth of its sulci, the number and thickness of its convolution, whence results a greater extent of its surface; and, lastly, the extent of the corpus callosum.

§ 740. The ancients, commencing with Galen, and many moderns, have regarded the nervous system as having a single centre in the encephalon, and prolongations (the spinal marrow and nerves.) It has already been seen that G. Bartholin transferred the nervous centre to the spinal marrow, which he did from the consideration that fishes have a very large spinal marrow, and a very small encephalon, and yet that these animals possess a great power of motion. Bichat, developing some ideas that had been vaguely advanced before him, respecting the action of the ganglia, proposed two distinct nervous centres, the one (the cerebral, or encephalic and spinal) subservient to the sensations accompanied with consciousness, intellect, and voluntary motion; the other (the ganglionary) subservient to the functions which are performed without consciousness and volition. In this latter he at the same time placed the seat of the passions. M. Cuvier considers the nervous system as a vast net-work embracing the whole an-

mal, and furnished with numerous centres and communicating cords. Dr. Gall divides the nervous system of animal life into those of the spinal marrow, the organs of sense, and those of the brain and cerebellum. M. de Blainville considers the nervous system as divided into as many parts as there are great functions, and defines it to be masses or ganglia and filaments, some issuing forth and going into the organ which they are to animate, which forms the particular life; others entering, and all terminating in a central mass, establishing the general life, and giving rise to the sympathies and relations. The central part, according to this ingenious physiologist, is the spinal marrow; another part comprises the ganglia of the organs of sense and motion; a third those of the viscera, viz. the cardiac and semilunar or cœliac ganglions; the fourth and last comprehends the great sympathetic nerve, which forms a centre to the visceral ganglia, and which, by the intervention of the ganglia of sensation and motion, connects them with the central mass.

All these divisions, which may be justified on various considerations, are not, however, so well marked, so absolute as their authors pretend. In man, the encephalon or some one of its parts, the spinal marrow, where it is embraced by the pons varolii, is certainly a centre to which the functions of all the other parts of the nervous system are more or less subservient. Indeed, in some of its functions, the spinal marrow may be considered as a centre nearly independent; it is the same with the ganglions, and finally, with the nerves; for no part of the system is reduced to the entirely passive condition of a conductor. This independence of the nerves, the greater independence of the ganglions, and the still greater of the spinal marrow, are otherwise so much the more distinctly marked, as this or that function is concerned, as they are observed in this or that animal, and as in man even they are observed at more or less advanced periods of development. These propositions, which may be regarded as the laws of nervous action, will be developed hereafter.

It is sufficient now to remark that there is no absolute separation between the parts of the nervous system. We shall

consider it successively as a whole, and in its principal parts, referring the details to special neurology.

SECTION I.

OF THE NERVOUS SYSTEM IN GENERAL.

§ 741. The nervous system* forms a continuous whole, ramified and reticulated, all the parts of which are connected.

§ 742. This system consists in a central mass, in nervous cords, and in ganglions.

The central nervous mass, which has not received a particular name, and which is designated by the term of brain in general, and sometimes by that of nervous axis, or cerebro-spinal organ, consists of several parts which are distinguished by their situation, into spinal marrow or rachiform cord (Ῥαχιτης μυελὸς) and into encephalon (Ενκέφαλος); by their form and texture, into nervous medulla, and into cerebrum, cerebellum, and tubercula quadrigemina; the rudimentary olfactory lobes are regarded as nerves.

The spinal marrow is a large cord single and median, divided by a double furrow, into two lateral portions, and by the insertion of the ligamenta dentata, into anterior and posterior fascicles. This cord contained in great part within the vertebral canal, extends into the cranium, and bears there the

* Th. Willis, *Cerebri anatome nervorumque descriptio et usus*, Genevæ, 1676.—R. Vieussens, *Neurographia universalis*; Lugd. 1684.—G. Prochaska, *de structurá nervorum tract. anat.*; *Ejusd. Commentatio de function. system. nerv.*; *in op. minor.*—Vicq-d'azyr, *Rech. sur la struct. du cerveau, du cervelet, de la moelle allongée, de la moelle épinière, et sur l'origine des nerfs, &c.*; in Mém. de l'acad. des sc. de Paris, 1781 and 1783.—A. Munro, *Observ. on the nervous system*; Edinb. 1783.—Ludwig, *Scriptores neurologici minores selecti, &c.*; Lipsiæ, 1791-95, 4to.—F. G. Gall and Spurzheim, *Rech. sur le système nerv. en général, et sur celui de cerveau en particulier*; Paris, 1809.—Rolando, *Saggio sulla vera struttura del cevrello dell 'uomo e degli animale, e sopra le funzioni del sistema nervoso*; Sassari, 1809.—Carus, *Anat. und physiol. des nerven systems*; Leipzig, 1814.

name of medulla oblongata. In this last part, besides the anterior and posterior fascicles, there is on each side a lateral fascicle.

The lateral fascicles, increased by the corpora olivaria, are prolonged, for the most part, into the tubercula quadrigemina, and terminate there. The posterior fascicles, after being enlarged in the corpus rhomboideus, expand in the cerebellum and form it; extending beyond, they unite on the one hand at the median line, under the medulla oblongata, where they form the annular protuberance or pons varolii, and on the other hand they unite with the tubercula quadrigemina. The anterior fascicles, after mutually crossing each other, united with a part of the lateral, enlarged in the optic thalami, and the corpora striata, expand in a radiated manner to form the hemispheres of the brain, and unite at the median line in the corpus callosum.

The nervous cords or the nerves, to the number of forty pairs and upwards, join the medulla by one extremity; they present a certain number of plexuses where they communicate with each other; numerous ganglions are met with in their course; the cords terminate by another extremity in the two teguments, the organs of sense, the muscles, and in the coats of the vessels, especially of the arteries.

§ 743. The form of the nervous system is, in general, symmetrical; the symmetry is especially marked in the central parts, still more so in the spinal marrow than in the encephalon, where the surface of the lobes of the brain, and cerebellum always presents irregularities. The nerves which are derived immediately from the spinal marrow, are all symmetrical, except the pneumo-gastric, which is distributed to asymmetrical organs: all, however, in their ultimate divisions, cease to be as rigorously symmetrical as in their trunks. The ganglions and the nerves, which belong to the asymmetrical organs of vegetative functions, participate in their central parts, but especially in their divisions and peripherical extremities, in the irregularity of these organs.

§ 744. The situation of the nervous system is interior and central with respect to its masses, and the nervous cords also

are deeply seated: the extremities alone of these cords reach to the two teguments of the surfaces of the body.

§ 745. The nervous system is formed of two substances, distinguished by their colour and their respective situation, into white or medullary, and gray or cortical.

§ 746. The white nervous substance, called also medullary, *medullaris*, because that for the most part it is enveloped by the other, presents several shades of white.

Its consistence varies a little in the different parts. It is in general less elastic than gelatine, but a little more glutinous, viscous or tenacious. The section is uniform in colour, and in appearance homogeneous: red points or sanguineous striæ are alone perceptible in it. This substance is really very vascular; when torn, the ruptured blood vessels become salient on its unequal surface.

The white nervous substance, plunged for some minutes in boiling oil, or for some days in alcohol, in weak nitric or muriatic acid, in acidulated alcohol, or in a solution of corrosive sublimate, augments in consistence; and if it is then attempted to distend or to tear it in any direction, a fibrous appearance is perceptible. White filaments as fine as hairs can be separated from it. The finest fibrils that can be obtained are so delicate and so closely united with each other, that it is very difficult to determine any thing relative to their length and the diameter of the finest of them, or of the primitive fibrils. These fibrils, parallel or concentric, are united in fascicles which have, with respect to each other, different directions. It is not known with certainty whether this fibrous disposition exists throughout the nervous system; it has been found wherever it has been sought for, and always the same in the same parts.

This fibrous structure is visible in some parts of the nervous system, without any preparation; almost every where more difficulty is experienced in tearing this substance in one direction than in another, and precisely in the direction which the chemical preparations show to be that of the fibres.

The white nervous substance, when dried, acquires a yellowish colour and a corneous appearance; cut into thin slices,

it becomes semi-transparent, plunged into water, it takes again its colour and its opacity.

§ 747. The gray substance,* *cinerea*, called also cortical, because it envelopes the preceding in many places, presents, like it, and even still more so, varieties in shade: it varies from lead gray to a blackish brown tint. This substance is always softer than the white. The surface of its section is uniform, and presents only points and red striæ, more numerous still than in the medullary substance. This substance, indeed, is, in some points at least, much more vascular than the white. That which forms the cortical substance of the brain and of the cerebellum contains so many vessels, that when it has been well injected, and afterwards macerated, it appears under the microscope entirely vascular. Albinus,† however, affirms, and with reason, that in this case even there remains one part evidently not capable of being injected, or extra-vascular. The gray substance, submitted to the same chemical preparations as the white, does not present an entirely similar fibrous appearance on being torn. Submitted to the action of water, the gray nervous substance becomes softer, swells a little, and loses a great part of its colour. Acids, alcohol, and especially corrosive sublimate, whiten it at the same time that they render it harder; on being afterwards dried, it becomes capable of being pulverized. The colour, a little variable according to the races and individuals, appears to be a product of the colouring matter of the blood.

§ 748. The two nervous substances are differently intermingled with each other in the different parts of the nervous system: in the lobes or hemispheres of the brain and cerebellum, the gray substance forms an envelope or cortex to the white; in the spinal marrow, the gray substance forms two interior cords, enveloped by the white substance; in the medulla oblongata and in the crura cerebri and cerebelli, masses or nuclei of the gray substance are found enveloped by the white, as well as alternate layers of the two substances, cords or fibres of both, which cross or traverse each other reciprocally; in

* Ludwig, *de Cinerea cerebri substantia.*

† *Acad. annot. lib. I. cap.* 12.

the ganglions, a peculiar gray substance, traversed by white fibres; finally, in the nerves white fibres alone.

The white substance alone forms a continuous whole. The gray substance, on the contrary, is only met with at intervals; it is found especially where the central extremities of the nerves are inserted; it has been supposed even to exist at their peripheral extremities, and especially in the corpus mucosum of the skin; it is found also where the white fibres increase and seem to expand, as in the crura cerebri and cerebelli; finally, it is found at the surface of the brain and cerebellum; it has been thought even, but without proof, that it existed in the ganglions.

The fibrous texture of the nervous substance had been formerly observed in the white substance by Malpighi, but he regarded the gray substance as *glandular.*

This idea of Malpighi respecting the gray substance, has been for a long time admitted in conjunction with the hypothetical opinion that the nerves are hollow or canaliculated. Afterwards, this idea of Malpighi, respecting the gray substance, gave place to that of a point of origin (Gall,) and of a centre of action, (Ludwig,) &c.

§ 749. The nervous substance, whether white or gray, on being examined with the microscope,* and enlarged about three hundred diameters, appears in all its parts composed of semi-diaphanous globules, united by a transparent and viscous substance. These globules have appeared to Delatorre different in size in the brain, cerebellum, spinal marrow, and nerves, the largest being in the brain, and the smallest in the nerves; these globules have appeared to him heaped together without order in the central nervous mass, and in linear series in the nerves; as to the liquid in which they are contained, it appeared to him slightly viscous in the encephalon, more so in the spinal marrow, and still more so in the nerves. These globules, and the liquid which surrounds them, furnished and re-

* J. M. Dellatorre, *Nuove osserv. micros.; in* Napoli, 1776.—Prochaska *de struct. nervor.*—J. and Ch. Wenzell, *de Penitiori struct. cerebri;* Tubing. 1812.—A. Barba, *Osserv. microsc. sul cervello e sulle parti adjacenti;* Napoli, 1807.—Home and Bauer, Philos. Trans.; ann. 1821.

paired continually by the arrival of arterial blood, are conveyed, according to him, from the brain, as from a centre, to all parts of the body, and reciprocally; their flux from the brain to the muscles causes motion, their reflux from the senses to the brain produces sensation. This inadmissible explanation should be separated from the sufficiently exact anatomical observation upon which it rests.

Prochaska having examined with the microscope a laminæ of nervous substance sufficiently thin to be transparent, found that it resembled a sort of pulp formed of innumerable globules or round particles; by the action of water, this pulp is divided into little flocculi, and each flocculus is composed of a certain number of globules; maceration, prolonged even during three months, is insufficient to separate the globules from each other. He concludes that the uniting medium is a delicate cellular tissue, formed in part by sanguineous vessels, and in part by prolongations of the envelope of the nervous system: the globules appeared to him different in size in the same part of the system; he estimates the size of those of the brain and cerebellum at about one eighth part of that of the globules of the blood; as to the structure of the globules themselves, the most powerful microscopes teach us nothing on that subject.

Barba has observed the globules, and has found no difference in the substance which unites them, in the different parts of the nervous system.

The brothers Wenzell have added some observations to these; they have found the nervous substance throughout formed of globules which they regard as vesicles filled with medullary or cineritious substance, according to the parts; the globules seem to touch each other or to adhere, and nothing is perceptible between them. This globular appearance resists desiccation, the action of alcohol, either pure or acidulated.

Messrs. Home and Bauer have published two different results of microscopic observations: according to their first researches, the fresh brain is composed of fibres formed by the reunion of globules nearly equal in size to those of pus. According to their new observations, the nervous substance is

composed of white, semi-transparent globules; some of them equal in size to those which form the nucleus of the coloured particles of the blood, others smaller, of a gelatinous substance, transparent and soluble in water, and of a liquid similar to the serum of the blood: the proportion of these three parts, the globules, the gelatine, and the serum, as well as the size of the globules, gives rise to the principal differences which the nervous system presents. The gray substance presents few distinct fibres not globular, it is formed especially of very small globules; the gelatinous substance, and the serous liquid are very abundant in it. The medullary substance of the hemispheres of the brain and cerebellum contains fibres formed of linear series of globules more distinct and more abundant; the greater part of the component globules are of a greater diameter: the gelatinous substance is more tenacious and in less proportion than in the gray substance. The corpus callosum and the medulla oblongata have especially the globules of mean diameter, the gelatinous substance and the serum are more abundant than in the hemispheres, and the first is less tenacious. In the nerves, globules of all diameters are found united into fibres, and these into fascicles. The gelatinous matter in question is found again in the blood, where it serves as a uniting medium between the particles of the colouring matter which surrounds the globules.

H. M. Edwards is publishing* at the present moment microscopic observations, according to which the nervous substance of the encephalon, of the spinal marrow, and of the nerves, in the four classes of vertebral animals, is composed of microscopic globules, 1-300 of a millimetre in diameter, united in series in such a manner as to form primitive fibres of considerable length.

I have verified these observations, the importance of which is so much the greater, as similar globules, but arranged a little differently, are found in all the tissues of animals.

According to Carus, the nervous globules are disposed in

* *Mémoire sur la structure élémentaire des principaux tissus organiques des animaux: Thèse;* Paris, 30 juillet 1823.

clusters in the central masses which act by radiation, and in regular lines in the nerves which act only as conductors.

§ 750. The cellular tissue, which unites the nervous fibrils, is soft and little apparent. This tissue is more condensed at the surface; where united with the vessels, it forms a membrane, more or less dense, more or less vascular; single for the nerves (neurilema), double about the nervous centre (pia mater and dura mater), having an interval with contiguous walls formed by a serous membrane (tunica arachnoides).

§ 751. The sanguineous vessels of the nervous system are very numerous. They ramify very much in the immediate envelope of this tissue (neurilema and pia mater); they afterwards penetrate into the gray substance, where they are extremely abundant; they penetrate finally into the white substance, in which they are much finer and less numerous. No lymphatic vessels have been discovered in the nervous system.

§ 752. The nervous substance has been examined chemically by Thouret, Fourcroy, and Vauquelin.

The analysis of the brain by Vauquelin, has given the following results; water 80.00; white fatty matter 4.53; reddish fatty matter 0.70; albumen 7.00; osmazome 1.12; phosphorus 1.50; acids, salts and sulphur 5.15.

According to the experiments of this able chemist, the spinal marrow and the nerves have the same composition as the brain.

John has recognised that the gray substance contains no phosphorus.

Chevreul has found in the blood a substance characteristic of the nervous matter, cerebrine.

§ 753. The vital properties of the nervous system distinguish it essentially from all other organs; besides the faculty, common to all parts of living bodies, of nutrition, it possesses another active property, altogether peculiar, which is called nervous force, nervous power, nervous influence; manifests itself by the functions of this system designated collectively by the name of innervation.

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§ 754. Innervation* too much restricted by those who confine it to sensation and volition, holds under its dependence, in a more or less distinct manner, all the phenomena of life. Modern physiologists in verifying this pre-eminence of the nervous system, have been enabled, supporting themselves by observations in comparative anatomy and physiology, by observations on the development of the embryo, and by physiological and pathological observations and experiment, to establish some laws of innervation. In general, the nervous system has so much the more influence upon the rest of the organization, as the animal more elevated in the series has this system more developed. In man the nervous system has so much the more influence upon the functions, as the individual is more distant from the state of an embryo, and at the same time has this system farther advanced towards perfection. The influence of nervous action upon another function is so much the more clearly marked, as this function is further removed from the state of a vegetative function. The influence of the nervous centre upon the rest of the system is so much greater and more necessary, as the centre is more developed, more voluminous relatively to the remainder of the system, and especially as the different parts of the central mass are more exactly collected together towards a single point; it is especially in this latter respect that the nervous system of man differs from that of other animals.

§ 755. The most elevated mental operations exercise themselves upon results, and manifest themselves through the medium of nervous action; it is then true to say that *man is an intelligence served by organs.*

Actions of combination, intermediate between sensation and volition, which constitute an appearance of intelligence, or the advanced instinct of vertebral animals, belong also to nervous action.

* Rolando, *op. cit.*, and *Journal de physiologie*, t. iii.—Georget, *de la Physiologie du systeme nerveux etc.* Paris, 1821.—Flourens, *Recherches physiques sur les propriétés et les fonctions du systéme nerveux, etc.*; in *Archives générales de médicine*, vol. ii.—Fodéré, *Recher. expériment. sur le systeme gerveux;* in *Jour. de Physiol.*, tom iii

The most limited instinct, which, in all animals, even the most imperfect, necessarily connect certain motions with certain sensations, is also a nervous action.

Sensation and volition, whatever may be the intermediate phenomena, are still actions of the same kind.

The phenomena of irritation, that is to say, impression not perceived and involuntary motion, are themselves more or less dependent on nervous action. In the intestinal canal, in the heart, &c., usually the impression is not perceived, and the muscular contraction is not voluntary, but notwithstanding the nervous system intervenes; for if in the regular order the impression does not pass beyond the ganglions, and if the muscular contraction is the necessary consequence, which is the character of irritability, in certain cases of extraordinary impressions, sensation results; also when the will is troubled by the passions, the interior muscular movements are perceived. In the vessels, and especially in the arteries, the nervous action is very evident. In the cellular tissue the impression and the contraction closely connected, and designated by the single name of tonicity, appear to be slightly dependent on the nervous system, but however are not altogether foreign to it.

The nervous influence is not limited to the organs or solid parts alone, the blood* experiences its effects.

§ 756. The nutritive and genital functions, also, are all more or less dependent on nervous action.

Digestion,† not only the sensations and motions which take place at the entrance of its organs, but even the action of the stomach, is obedient to the nervous action; it has been known for a considerable time that the section of the nerves of the stomach deprives this organ of the faculty of digesting and pushing forward the aliment into the intestines.

Respiration is not less dependent on nervous influence; the

* G. A. Treviranus, *Biologia*, B. 4, page 646.—*Idem*, *Vermischte Schriften*, &c. B. I., page 99.

† A. Brunn, *Experim. circa ligat. nervorum.*—Vavasseur, *de l'influence du systeme nerveux sur la digestion stomacale: Thèse.* Paris, 12. août. 1823.

section of the nerves of the lungs brings on speedily asphyxia and death.

The circulation, especially the action of the heart and capillary arteries, is equally under the same influence.

Secretion is also evidently under the influence of the nerves. Direct experiments show that the section of the nerves of an organ, suspends its secretion. Inhalation or absorption is equally modified by the nervous action. Nutrition or organic formation, without being an immediate result of the nervous power, notwithstanding obeys its influence. Animal heat is still more evidently dependent. The physiological experiments of Messrs. Brodie and Chossat have placed this influence beyond all doubt: the chemical and physiological experiments of Messrs. Dulong and Despretz have demonstrated that this heat can not depend entirely on respiration.

We see even in generation, that, the sensations and voluntary motions which accompany it, the motions of irritation, the phenomena of secretion of the sperm and formation of the ovules, those of the nutrition and growth of the fecundated ovum, are all, but more or less directly, dependent on nervous action.

§ 757. Sympathy or the co-existence of two phenomena of formation, of irritation, of sensation or of volition, in the different parts, and by the action of a single agent, the most extraordinary fact of organization, is yet an effect of nervous action.

§ 758. What relation is there between the different parts of the nervous system with respect to its functions? Is there a single centre, either the spinal marrow, or the encephalon? or are these two centres, viz. one cerebral and one ganglionary? or finally, are there as many distinct centres as there are principal organs or great functions? These opinions, all founded upon observation, are all true within certain limits.

In the adult man, the nervous system forms a single system, all the parts of which concur in the action of the whole, in innervation, but besides each one in its proper function. Thus the brain and the cerebellum, besides their particular functions, augment the energy of the spinal marrow; this last

augments that of the nerves. In the adult man, the encephalon, and more precisely the mesocephalon, that is to say, the cranial extremity of the spinal marrow, the place from which spring the crura cerebri and cerebelli, is truly the centre of the action of the nervous system.

§ 759. What relation exists between the two substances of the nervous system, and what is their particular use?

Gall regards the gray substance as the matrix of the nerves, as a fertile layer in which the nerves take root, and on which depends their nutrition and growth. If Gall means by this that there is a true production or vegetation, he is wrong: for on the one hand no part is the product of another, all are deposited by the vessels, each one in its place; and on the other hand, the white substance appears before the gray, both in the animal kingdom and in the embryo. If he wishes to speak only of an insertion, he was right. We ought to regard with Ludwig, Gall, Carus, and Tiedemann, the gray substance as a centre of activity, as fortifying the action of the white parts which are implanted therein, in so much especially as it produces this effect by the great quantity of arterial blood which traverses it. This substance abounds in the spinal narrow, where the largest nerves are attached; it abounds equally in the corpus rhomboideum of the cerebellum, and in the optic thalami and corpora striata of the brain, as well as at the surface of these two organs in man.

§ 760. What is the particular function of each part of the nervous system?

The nerves (*sect.* ii.) conduct the impressions of the surfaces to the centre, and the principle of motion from the centre to the muscles and vessels.

The ganglions (*sect.* iii.), in consequence of the quantity of blood which is distributed to them, and by that of their particular texture, modify the nervous action.

The central nervous mass fulfils the most important parts of innervation; it is the instrument of intelligence.

The actions of combination, intermediate between sensation and volition, are also functions of the encephalon.

Instinct equally intermediate between these two orders of

phenomena, if it is attached to a particular nervous part, has probably its seat in the superior part of the spinal marrow.

It has often been attempted to determine, by observation and experiment, the organic seat of sensation and volition.

Rolando regards the hemispheres of the brain as the seat of these two actions, and the cerebellum as the organ which sends to the muscles the motive principle under the direction of the brain.

According to Flourens, the spinal marrow, at the place where it is surmounted by the tubercula quadrigemina, is the common point of the arrival of the sensations, and of the departure of the nervous influence of muscular motion. The cerebellum, according to this physiologist, balances the motions or arranges and regulates them; according to him the abstraction of the cerebellum renders the animal incapable of acting in a regular and proper manner, with respect to station and locomotion.

Magendie, supporting his position by the experiments of Lorry, Legallois, and his own, thinks that sensibility is inherent in the spinal marrow. This able physiologist is of opinion that the will or the faculty of determining muscular motions, resides in the most elevated part of the cranial portion of the spinal marrow, even in the optic thalami and the crura cerebri; that the optic thalami are necessary to lateral motions; that the hemispheres of the brain are necessary for the production of anterior motions, and the cerebellum for motions in the opposite direction. The removal of one or the other of these organs suppresses its action, and determines the irresistible action of the other; the removal of an optic thalamus determines a rotatory motion.

Foville and Pinel Grandchamps have been led by observations in morbid anatomy, to which they have joined experiments on animals, to establish the seat of sensibility in the cerebellum, and that of voluntary motion in the medullary substance of the hemispheres; the anterior part and the corpora striata for the abdominal members, the optic thalami and the posterior part of the hemispheres for their superior members.

Dugés,* by ingeniously bringing together physiological and pathological facts, places the seat of sensibility in the cerebellum, and that of voluntary motion in the hemispheres of the brain, admitting that the sensation is transmitted to the side of the cerebellum corresponding with the impression; on the contrary, as has been known for a long time, volition is transmitted from one side of the brain to the opposite side of the body.

These different opinions, contradictory in some points, rest all of them upon facts more or less well observed; new facts are necessary to dissipate the uncertainties which still remain upon this subject.

The transmission of sensation takes place by the posterior part of the spinal marrow, and that of motion by its anterior part. There are, as will be seen hereafter, special nerves for each of these functions.

The spinal marrow, which in these functions has only the office of a conductor, is the seat or the origin of the principle of irritability. If the spinal marrow of a living animal be divided in its middle, the posterior part of the body becomes insensible and immoveable. If the skin of this part of the body be irritated, the irritation, though not perceived, determines involuntary motions in the muscles of this part. If the spinal marrow be removed, and in consequence the central connections of the nerves destroyed, movements of irritation in the skin can be no longer excited.

The circulation is under the influence of the entire spinal marrow, and of all the motory nerves which are derived from it; the particular action of the heart also, but mediately, being immediately under the influence of the sympathetic nerve. Respiration is under the direction of the superior and lateral part of the spinal marrow; digestion under the combined influence of the par vagum and sympathetic.

Secretion, absorption, vital heat and nutrition, are under the influence of all parts of the nervous system.

§ 761. Nothing is known respecting the manner in which

* *Mémoire inedit.*

the nervous system acts. This fact escaping observation, a multitude of hypotheses have been proposed, varying with the prevailing doctrines at each epoch.

An attempt has been made to explain nervous action by mechanical hypotheses, either by supposing that the nervous fibres could vibrate in the manner of cords, or by admitting such vibrations only in their elementary fibrils, or in the spinal fibrils which have been supposed, or finally by an oscillation of elastic globules, the existence of which has been imagined.

Other explanations have been founded on the supposition of a nervous fluid, either material and visible, or more generally an incoercible fluid; and, in this latter supposition, it has been called sometimes ether, sometimes phlogistic or magnetic, luminous, electric, latterly galvanic, according to the objects which have engaged at different epochs the attention of natural philosophers.

Reil has proposed on this subject an hypothesis which consists in deriving the nervous action from a chemico-vital process. He attributes in general the action of organic parts to their form and composition. The form and composition of organic parts being changed, their action is always so; and whenever the action is changed, there are changes observable in the parts; so, that as a general rule, the change of action is a consequence of the change of composition in the parts: nervous action then supposes a change in the nervous substance. What appears particularly favourable to this hypothesis of Reil, is the abundance of arterial blood which is distributed in the nervous system, and especially in the gray substance, the volume of which is always proportionate to the nervous activity (759).

§ 762. We may, independently of every hypothesis, consider the nervous action as a general fact, and observe its phenomena and conditions. The phenomena of innervation are insensible in the nerve, as those of muscular contraction are in the muscle: nothing is visible there; however, some facts seem to indicate that there occurs in the nervous substance, when in action, a motion of some kind, in order to produce sensation. The sensation

resulting from the impression made by the light upon the eye is not instantaneous; the vibration or the pressure of the eye in darkness gives the sensation of light, &c. Many other facts collected by Darwin seem to indicate that there is in sensation a molecular movement of the nervous substance which is not instantaneous. On the other hand, many facts seem to indicate that the nervous system is the forming and conducting organ of an imponderable agent analogous to electricity or galvanism. This nervous agent, whose existence was foreseen by Reil, recognised by Humboldt and by Aldini, admitted and sustained with so much talent by Cuvier, allows an easy explanation of all the phenomena of nervous action, and particularly the relation which exists between the benumbing nervous action of electrical fishes and galvanic phenomena on the one hand, and ordinary nervous action on the other; the possibility of exciting galvanic phenomena by the nerves and muscles alone; the possibility of exciting muscular contractions, the chymifying action of the stomach, the respiratory action of the lungs, &c., by replacing nervous influence with galvanic action; the existence of a nervous atmosphere, acting from a distance on the nerves and muscles, and across the solution of continuity of divided nerves; the wrinkling which takes place in the muscular fibre in contraction, and the relation of the ultimate nervous fibres, transverse with respect to these wrinkles, is a phenomenon which approaches certain electro-magnetic phenomena, &c.

These opinions have appeared so probable to Rolando, that he has sought the source of the nervous agent of contraction in the cerebellum, which, on account of its laminæ, has appeared to him to act in the manner of a voltaic pile, and has admitted in sensation a molecular motion of the pulp.

However that may be, the nervous power is weakened and exhausted by intellectual operations, by the exercise of the senses, of the muscles and of the encephalon, and still more by pain; it is restored by rest, food, and sleep. Its energy, generally and particularly, is relative to the entire mass of the nervous system and of its parts, and especially to the mass of the gray substance, which is the most vascular; it is relative

also to the extent of surfaces. It remains sometimes after death, in the nerves and muscles.

This power seems to result from the action of a subtle fluid, formed by the organic action of the nervous substance bathed with the arterial blood. It appears that this fluid is formed throughout, but especially where there are masses of the gray and vascular substance. This subtle fluid seems to traverse the interior and the surface of the nerves, form an atmosphere about them, and, beyond their extremities, penetrate and impregnate all the organs and the humours themselves. The blood in particular seems to be penetrated with the same fluid, and to owe to it the essential properties which distinguish it during life.

In the mean time arterial blood furnishes the nervous system with the material of its action; the arrival of arterial blood is also a condition of this action.

Asphleyxia, the cause of which has been sought for in the interruption of the passage of the blood through the lungs, (Haller,) in the arrival of the blood, which had remained venous, in the left ventricle (Godwin,) in this blood penetrating into the muscular substance of the heart (Bichat,) is produced rather by the dark blood penetrating into the nervous substance; syncope in the same manner depends on the innervation being cut off from the heart: life being essentially connected with the reciprocal action of the blood upon the nervous substance, and of the nervous substance upon the blood.

Does the nervous agent result directly and solely from the reciprocal action of the blood and nervous substance? is it drawn from without? can it pass from one individual to another? does it result from the opposition of the white and gray substances? of the action of the nervous fibre upon the muscular fibre? Nervous action may then be compared to a discharge of electricity.

§ 763. Nervous action is excited or put in play by external or internal stimuli.

§ 764. The first moments of the formation and development of the nervous system, can not be observed. Does this system exist from the beginning, and does generation result

only from the uniting of the cellulo-vascular system furnished by the mother, with the nervous system furnished by the male (Rolando)? Does the nervous system commence with the formation of the cardiac ganglion, and develope itself successively by the great sympathetic nerve and the rest of the system* (Ackermann)?

What observation teaches us, is, that the nerves and the spinal ganglions are formed before the spinal marrow, and this latter before the encephalon, that is to say, before the cerebellum, the tubercles, and the brain.

The spinal marrow, at first open behind like a groove, then canaliculate, by the approaching of its borders, becomes finally solid. It occupies at first the whole length of the vertebral canal. The white substance which forms the exterior is first deposited; the gray substance being deposited afterwards in the interior, fills its cavity.

The cerebellum, tubercles, and brain, which constitute at first only the larger parts of the groove of the spinal marrow, reverse themselves, meet, and unite at the median line, presenting in the different places of their development, the most exact resemblance with the same parts of fishes, reptiles, birds, and mammalia, in ascending from the rodentia to the quadrumana [739].

In the brain as in the rest of the encephalon, and as in the spinal marrow, the increase in thickness takes place simultaneously, exteriorly, and interiorly. It is by this circumstance that we must explain, with Desmoulins, the existence of a cavity which is found in the fœtus, within the centrum ovale of Vieussens, between the interior and exterior layers of the vault of the lateral ventricles.

In the encephalon as in the spinal marrow, the gray substance is only formed after the white, and even only after the fibres of this latter are united by commissures upon the median line.

After birth, the increase of the nervous system, previously so

* Ackermann, *de systematis nervei primordiis.* Heidelb. 1813.—Tiedemann, *op. cit.*

rapid, becomes much slower: after the internal ear and the eye, it is the part of the body which then grows the most slowly.

In old age, the nervous system experiences a sensible diminution in volume, which manifests itself in the encephalon by the narrowing of the cranium,* and that can be established also by measuring the spinal marrow.

§ 765. The nervous system is also subject to many errors of conformation.† One case is known of a total deprivation of the nervous system: it has been observed in an acephalous fœtus reduced to a little trunk without form. There are several cases of the absence of the encephalon and of the head. There are a great many cases of the total absence of the nervous centre, the nerves and the spinal ganglions existing. There are a still greater number of cases of the absence of the encephalon, the spinal marrow existing, as well as all the nerves of the face and neck. The spinal marrow may remain open, hollow, or extended throughout the whole canal. In certain cases the cerebellum and tubercles exist, as well as the crura cerebri and their optic and striated enlargements, and the hemispheres alone are wanting. In some cases the hemispheres are incomplete; the middle and posterior lobes are deprived of furrows and convolutions. Sometimes the corpus callosum only is wanting;‡ or there remains a cavity within the hemisphere, or in the septum, &c. The cerebellum may present analogous defects, especially in the number of its laminæ.§ All these cases are imperfections or defects of development.

* Tenon, *Recherches sur le Crâne humain*, Mém, de l'Inst. sc. phys. et Math., tome I.

† A Béclard, *Mémoire sur les fœtus acéphales;* Paris, 1815.—Geoffroy Saint-Hilaire, *Philos. anatom.*, vol. ii.—Breschet, *Diction. de Méd., art. Acéphale, et Anencephale.*—C. P. Ollivier, d'Angers, *Essaie sur l'anatomie et les vices de conformation de la moelle épinière;* Paris, 1823.—Id. *Traité de la moelle épinière et de ses maladies, un.* vol. 8vo.—Laroche, *Essaie d'anat. pathol., sur les monstruosités de la face;* Paris, 1823.

‡ Reil, *Archiv. für die physiologie*, tom. xi.

§ Malacarne, *Neuro encephalotomia;* Pavia, 1791.

There may exist defects of symmetry, and defects of proportion between the different parts of the system.

§ 766. The consistence of the nervous system is sometimes changed. Softening* is an alteration very frequent in a part of the central nervous mass. The softened nervous substance is sometimes so much so as to be almost liquid. Its colour is sometimes milk white; at other times it is yellowish, rose coloured, red, or brown. This alteration is met with in the optic layers, in the corpora striata, in the hemispheres of the brain, in the cerebellum, in the medulla oblongata, and even in the spinal marrow. It gives rise, according to its seat, to different derangements of the sensations, of the voluntary motions, and of the other functions of the nervous system. It is often the result of an inflammation; in some cases it appears independently.

The hardening† of the nervous system has been observed by Esquirol, and by S. Pinel, who has very well described it. The hardened nervous tissue presents a compact mass, organic in appearance; it resembles in colour, consistence, and density, the white of an egg much hardened by cooking; no blood-vessels are perceptible; it appears contracted. The hardening appears to affect particularly the white substance. It has been observed in the bodies of idiots, in the brain, cerebellum, and spinal marrow, where it renders the fibrous disposition of the white nervous substance very manifest.

§ 767. The nervous system is subject to many affections.‡ the principal of which are, in the central mass, sanguineous congestion with or without effusion; inflammation and its various degrees; the different products of chronic affections, as encysted abscesses, the production of tubercles, of schirrus, of cancers, of fibrous tumours and osseous, of hydatids, and of foreign bodies. The membranes which envelop the central nervous mass are equally the frequent seat of sudden congestions with sanguineous or serous extravasation, of acute in-

* Rostan, *Recherches sur le ramollissement du cerveau*, 2d. edition; Paris, 1823.

† Pinel, jr. *Recherches sur l'endurcissement du système nerveux;* Paris, 1822.

‡ Lallemant, *Recherches Anat. path. sur l'encéphale et ses dépendances.*

flammation in different degrees, of chronic inflammation; acute and chronic hydrocephalus are also met with. The affections of the nervous substance, may be complicated by those of its membranes.

The affections of the spinal marrow are more rare in man than those of the encephalon; the contrary takes place in animals.

These different alterations, according as they are acute or chronic, according as they act by irritating, by destroying, or by compressing, and according to their seat, bring on different derangements more or less serious, in the functions of the nervous system.

§ 768. The nervous tissue is not produced accidentally; the affinity established between this tissue and the encephaloid production, by Maunoir, rests upon insufficient analogies.

The nervous tissue on being wounded cicatrizes, when the wound is of such a nature as to permit the individual to survive.

Wounds of the encephalon, and of the spinal marrow, when they are not mortal, unite like those of other parts. Wounds of the encephalon, with loss of the substance of its envelopes, heal by the formation of an exterior cicatrix. This fact has been observed by Dumeril, in salamanders, and by many surgeons, in the human species. Wounds with loss of the substance of the brain, the cranium remaining entire, heal by the formation of a new substance, soft, mucous like, which does not altogether resemble that of the organ, and by the enlargement of the corresponding ventricle of the brain. Tearing of the encephalon, produced by sanguineous extravasation, presents, when the individual survives, remarkable phenomena. The blood is soon surrounded by a layer of organizable lymph; this layer becomes vascular and unites with the nervous substance; the blood is gradually absorbed, or at first the fibrine and the cruor, and then there remains the serum;* or at first the serum, and then there remains a fibrinous coagulum† to

* Riobé, *Observations propres à résoudre cette question: l'apoplexie, &c., est-elle susceptible de guérison?* Paris, 1814.

† Rochoux, *Recherches sur l'apoplexie;* Paris, 1814.

which the cyst unites: in the end the whole of the blood being absorbed, the cyst, contracting by degrees, forms adhesions, and becomes a yellowish cicatrix which perhaps finally disappears.

The cicatrices and the other alterations of the nerves will be examined hereafter.

§ 769. The nervous system, which holds so high a station in the regular exercise of the functions, fulfils one as important in the production of diseases:* it is that which receives and which propagates the impression of morbific causes, which determines the irregular motions of the muscles, of the heart, and of the arteries, which produces morbid sympathies; and as its action extends to the cellular tissue which forms the base of the organs, to the blood which penetrates and bathes them, one may conceive that it is foreign to no morbid action, and that it is the principal agent of a great number among them.

The maladies called general, essential, or dynamic, have no more probable seat than the nervous and vascular systems, the centres of the animal and vegetative functions, than the blood and the nervous agent which traverse them, and which are in a mutual, intimate, and necessary dependance.

It is in the regular relation of these two great systems and of their functions, that life and health consists; it is from the the derangement of their harmony, that disease and death result.

SECTION II.

ON THE NERVES IN GENERAL.

§ 770. The nerves,† *nervi*, are white cords formed of medullary filaments, attached by one extremity to the nervous

* Georget, *op. cit.*—Lobstein, *Discours sur la prééminence du système nerveux;* Strasbourg, 1821.

† J. C. Reil, *Exercitationes anatomicæ de structura nervorum;* Halæ, 1797, fol.

centre, and by the other to the teguments, the organs of sense, the muscles, and the vessels.

§ 771. The anatomists of the Italian school were sufficiently well acquainted with all the pairs of nerves which are known at the present time; but they did not class, number, or name them as is now done.

Willis gave them the numerical names and proper names under which they have been generally known since his time, viz.

1st. The olfactory nerves;

2dly. The optic or visual nerves;

3dly. The motory nerves of the eyes;

4thly. The pathetic nerves of the eyes;

5thly. The fifth pair;

6thly. The sixth pair;

7thly. The seventh pair, composed of a portio dura and a portio mollis or auditory nerve;

8thly. The eighth, or the par vagum, with its spinal or accessory nerve;

9thly. The ninth pair, or the motory nerves of the tongue;

10thly. The tenth pair, or the sub-occipital;

The nerves of the spinal marrow;

And the intercostal or sympathetic nerve.

Sœmmering has modified the division of Willis. He establishes forty-three pairs of nerves, of which twelve pairs are nerves of the brain: dividing the seventh pair of Willis into seventh or facial, and into eighth or auditory; his eighth into ninth or glosso-pharyngeal, into tenth or par vagum, and into eleventh or accessory, the twelfth is the hypo-glossal; and rejecting the sub-occipital among the spinal nerves, which are then thirty pairs in number, the great sympathetic nerve forms the forty-third pair. These modifications have been generally adopted.

Bichat divided the encephalic or cranial nerves, into those of the brain, those of the protuberance, and those of the medulla oblongata. This division is not founded upon exact observations.

The nerves may be exactly divided, 1st, into nerves with

double roots, one arising from the anterior column and the other from the posterior column of the spinal marrow; these are the spinal nerves, the sub-occipital and the trigemini, or the fifth pair of the cranial nerves. These nerves serve at the same time for sensibility and for muscular motion. 2d, Into nerves with a single root: these are the first, second, and eighth* pairs, or the olfactory, optic, and auditory nerves; and the third, fourth, and sixth, or the motor nerves of the eye; and the twelfth or the motor nerves of the tongue. These nerves serve exclusively, some for sensibility, the others for muscular motion. 3d, Into respiratory nerves, vocal, and of expression: they arise from the lateral fascicle of the superior part of the spinal marrow; these are, according to Ch. Bell,† to whom we owe an exact knowledge of them, the par vagum, which is the centre of this system, the facial nerve, the glosso-pharyngeal, the spinal or accessory, the diaphragmatic, and the external thoracic. 4th, Into circulatory nerves: they arise from all the spinal nerves; these are the great sympathetic nerves. These last and the par vagum are connected besides with the interior tegument, with the glands and the interior muscles in general. The sympathetic nerve will be described separately in the following section.

§ 772. The form of the nerves is, in general, cylindrical. Their branches are, as in the vessels, larger taken together than the trunks which furnish them: the nerves consequently enlarge from their origin to their termination; they also swell a little at their origin. Their surface presents wrinkles or transverse striæ, which depend on the elongation which they experience in different movements; these wrinkles are easily perceived with a lens, especially in the nerves of the members.

There are three things to consider in the nerves; 1st, their origin; 2d, their course; 3d, their termination.

§ 773. We must not understand by origin of nerves, the

* This must be a mistake that our illustrious author has overlooked while correcting the proof; for the auditory nerve is the seventh and not the eighth pair. TRANS.

† Phil. Trans. 1822, part 1 and 2.

point from which they spring and upon which they vegetate, if we may so express it: this origin is only the central extremity of the nerve, or that by which it is connected with the nervous centre. It is for all the nerves in the spinal marrow and in the medulla oblongata; no one arises from the lobes of the brain nor from the cerebellum. The olfactory nerve is not even an exception to this rule; this nerve arises from a prolongation of the spinal marrow, which, in animals, constitutes the olfactory bulb. Sometimes fœtuses are found deprived of the brain, and in which notwithstanding the olfactory with the spinal marrow and the crura cerebri exist, as I have had occasion to observe lately. Bichat, in saying that all the nerves arise from the medulla, makes an exception for the optic and olfactory which does not really exist.

The origin of the nerves is often more deeply situated than it appears at first; so that the point from which they detach themselves is often not their true origin: the fifth pair, for example, does not arise from the pons varolii, from which it appears to come, for the pons varolii does not exist among oviparous animals, where the origin of this nerve notwithstanding is the same as in the mammalia. We need not, however, seek to pursue the origin of the nerves beyond the reach of the senses, and suppose them to set out from the brain or from the cerebellum, as has been done to support hypothetical explanations.

It has been asked if the nerves cross each other at their origin; and it has been affirmed without hesitation that it is so, to explain pathological phenomena in which the cause and the effect, both seated in the nervous system, present a sort of crossing. Let us see what observation teaches on this subject. There is no sensible crossing in the nerves of the medulla oblongata. It is the same with those which arise from it where it is prolonged into the cranium, except perhaps the optic nerves, in which there appears to exist at least a partial crossing. Authors, in effect, do not agree as to the mode of union of these nerves. Their crossing, admitted by some, denied by others, is evident in fishes; but in man, although in most cases the atrophy of one of these nerves continues on the opposite side, observers worthy of credit assure us that they have seen

it continue on the same side. Dissection, moreover, does not show that the crossing takes place in all the fibres; so that the opinion of those who think it only partial is the most probable. But, this exception aside, the crossing of the nerves is far from being demonstrated. As much may be said of that of the two sides of the brain and cerebellum, which has been admitted. The anterior pyramids alone present this disposition, which explains how, in affections of the brain, the symptoms manifest themselves on the opposite side of the spinal marrow: thus, when this last is divided beneath the place where the crossing of the pyramids takes place, the symptoms appear on the same side.

Another question which has been agitated among anatomists, is to know if the nerves unite on the median line by commissures analogous to those which are found between the corresponding sides of the brain and cerebellum. This reunion is evident only in the pathetic nerves. The auditory nerves are also sometimes united, at their origin, by white striæ, which spread over the bottom of the fourth ventricle; but these striæ are far from being constant, and are generally wanting in youth.

Almost all the nerves have a deep origin from the gray substance, and not from the white, which covers this last, and under which they only dip. In the spinal marrow the nerves, on being torn up, leave a pit, which shows that they do not stop at the surface; and when the spinal marrow is hardened, the roots of the nerves may be followed and seen traversing the longitudinal fibres of this organ, to implant themselves in the gray substance. In the cranium this disposition is also evident as respects most of the nerves. The auditory alone have their origin at the surface of the medulla oblongata; but there exists at the same time the gray substance in the place from which they spring: only this substance is superficially placed; it forms the gray band.

The nerves of the spinal marrow arise with two roots, one anterior and one posterior, as has been said already. The respective size of these two roots, upon which there have been many different statements, and which Gall has said to be in favour of the posterior root, is so really only in the brachial nerves; the contrary takes place in the crural. These roots

unite in the intervertebral foramen, where the posterior presents a swelling or ganglion, with which the anterior is simply in close contact. This last does not concur in forming this ganglion, as is said in the greater part of the treatises on anatomy, although this peculiarity was pointed out long ago by Haase, Munro, and Scarpa, to whom even the discovery has been attributed. Gall only remarks, that at the neck the anterior roots of the spinal nerves are soft, pulpy, and reddish; which has deceived the anatomists who have examined this region. In the cranium the nerves present no such distinct roots. At the place where the nerves detach themselves from the medulla oblongata, the neurilema abandons them or becomes softened, and confounded with the pia mater, and the medullary substance alone is continuous with that of the encephalon. The interior filaments of the nerve are sooner abandoned by the neurilema than the exterior filaments: it follows, that where the nerve is torn, it breaks farther outwards than inwards, and there remains a prominence which has been erroneously compared to an apophysis upon which the nerve is implanted.

§ 774. In their course, the nerves branch, preserving nearly the same size in the interval of their divisions. These last consist only in a separation of the component filaments, and do not resemble those of vessels. The divisions of the nerves are in general accompanied by those of the vessels, although they do not always exactly correspond. The nerves communicate with each other in three different manners: 1st, by anastomoses; 2d, by plexus; 3d, by ganglions.

§ 775. By *anastomosis* is understood the uniting of two nerves. This union was thus named by the ancients, because they regarded the nerves as vessels in which the nervous fluid circulated, and compared them, in this respect, to arteries. This expression, which has been criticized, is convenient enough; for there is not, in anastomoses, a simple application of the nervous filaments, but a true communication of these filaments, a junction of their canal, which in truth contains a substance which remains there, and not a circulating fluid, as was supposed formerly. The anastomoses take place sometimes between the branches of the same nerve, sometimes be-

tween different nerves, rarely between the nerves of one side and those of the opposite.

It is especially in the nervous arches that the junction of the filaments is the most evident: the most remarkable of these arches is that which results from the union of the par vagum of the right side and of the solar plexus, and which Wrisberg has described under the name of *ansa communicans memorabiles.*

A plexus is only multiplied anastomoses. Scarpa* has given a very good description of them; but he is wrong in assimilating them to the ganglions. The manner in which the four last cervical pairs unite with each other, and with the first dorsal, to form the brachial plexus, furnishes a remarkable example. The cervical, lumbar, sciatic, plexuses, &c. are also examples in point. These plexuses are so disposed that the nerves which arise from them derive their origin at once, for the greater part at least, from a certain number of the nerves which constitute them.

Bichat admits that there is in plexuses something besides a simple intimate mixture of the nerves. Munro says that they contain gray substance, and may be considered a new origin of the nerves which depart from them; but this is by no means demonstrated.

The ganglions consist of tumours which contain, besides the nervous filaments, a substance which is foreign to them; the nervous filaments which are there mingled are much finer; they present, consequently, a greater complication than the two other modes of communication. They will be examined after the nerves, from which they differ in several characters.

§ 776. The termination of the nerves takes place after they have traversed the anastomoses, the plexuses, or the ganglions, or directly without their being interrupted from their origin. The manner of their termination is rather obscure. They are seen only to be deprived of their neurilema towards their latter extremity, and to become in consequence very soft; so that it is then very difficult to trace them. They swell in

* Anat. annot. *de gangliis et plexubus.*

general as they approach their termination; they become flat, and are then no longer visible while it appears that they should still be so. There exists two hypotheses upon the final termination of the nerves; one is not perhaps better founded than the other. According to one of these hypotheses, the nerves lose themselves, so to speak, in the organs, identifying themselves with their substance, which is imbibed with them, if we may use the expression. According to the other, which belongs to Reil, the nerve, not being capable of expanding throughout every organ at once, is surrounded with a nervous atmosphere in which it extends its action, nearly as is seen in electric phenomena. What has led to these hypotheses, is this remark, that the nerves expand into parts the extent of which is much greater than their own, even after they are divided as far as the eye, armed with a microscope, can follow them, as is seen in the muscles, the skin, the senses, and that notwithstanding each point of these parts, however small it may be, presents, when it is punctured, the same phenomena as when the nerve itself is punctured.

The different parts do not receive an equal number of nerves. The organs of sense are those which contain the most: the eye and the ear, present membranous expansions entirely formed of nervous substance. The skin, particularly at the hands and the lips; the mucous membranes, as well on the exterior as the interior; the glans and the different parts of the vulva, placed at the point of junction of these membranes with the skin, receive most nerves after the principal organs of the senses. Then come the exterior muscles, afterwards the interior, the blood vessels, among which the arteries receive more than the veins, or the lymphatic vessels in which their existence is not certain. The existence of the nerves is doubtful in the other parts, or in those which have cellular fibre for their basis, if the vessels are excepted, as the cellular tissue, the serous and synovial membranes, the cartilages, the bones, &c.: these parts, in fact, do not appear to receive nerves. Finally the corneous parts and the epidermis are certainly deprived of them. It is possible, on the contrary, that they exist in the preceding tissues, and that their softness or their

extreme tenuity conceals them from the eye: what may induce us to admit this, is the sensibility which these tissues present in diseases. It is true that the hypothesis according to which the nerves act by means of an imponderable fluid, susceptible of extending its influence beyond their apparent termination, may explain, to a certain point, this phenomenon. According to this hypothesis, nervous action is transmitted beyond the nerves, and across the organic substance, as nutrition takes place beyond the termination of the arteries, by a sort of imbibition.

It is worthy of remark, that in some circumstances where there exist paralysis of sensation, and not of motion, the inflammations which develope themselves are not accompanied with pain; which would lead to the opinion that these same cords are the seat of general sensation and of painful sensation, peculiar to inflammation, and that it is not solely the nerves of the blood vessels which cause this last to be experienced.

§ 778. The parts in which the peripheric extremities of the nerves terminate in the most evident manner, are then the tegumentary membranes and the senses which form a part of them, the muscles and the arteries.

The senses* are organs more or less complicated, by means of which external bodies are perceived; they have a structure calculated to receive an impression; they are connected with the nervous centre by nerves very much developed: these organs are those of tact or touch, of taste, of smelling, of hearing and of seeing.

The muscles are connected with the nervous centre by numerous and greatly ramified nerves (662). The arteries receive a great number of nerves; but they are not all distributed in the same manner: 1st, some only accompany them and surround them as the ivy surrounds trees, without penetrating into their tissue, unless perhaps after having accompanied them for a greater or less distance: such are those which accompany the vertebral arteries, the internal carotids and the

* *See* Blainville, *Principes d'Anat. comparée*, t. i. Paris, 1822.

facial; 2d, the others, adhering to the external membrane of the artery, penetrate with it into organs which are soft and pulpy: after becoming much ramified they disappear, and seem to dissolve in the external membrane; 3d, finally, notwithstanding the denial of Behrends, nervous ramifications are seen traversing the external membrane of the arteries, and terminate in the middle membrane. The nerves of the arteries belong either to the sympathetic nerves, or to the spinal and trigemini.

§ 779. The structure of the nerves has been examined by different anatomists. Della Torre found there fibres and the globules common to all the nervous system; Prochaska and Reil have made better known their interior disposition. According to their researches, the nerves are composed of cords, and these of very fine filaments, whose tenuity is equal to the filaments of silk, and which, in the optic nerve alone are equal in size to a large hair. These filaments, which are of the same nature as the medullary fibres or filaments of the brain and spinal marrow, differ only in being more distinct, more clearly separated from each other; and in being surrounded by an envelope or proper membrane: this envelope is called neurilema, *neurhymen*, which signifies membrane of the nerves; Galen made use of this expression, of which Reil first made a precise application. The neurilema forms a general envelope to the nerves, and furnishes partial envelopes to the nervous cords, as well as to the component filaments: it resists strongly. When it is empty, it represents an assemblage of little canals. These canals uniting together, open into each other at different distances. It is not then correct to say that the nerves are composed of filaments separate throughout their whole length; the communications of these filaments with each other make them no longer the same: examined on the superior and inferior part of the nerve, the nervous cords are not simply adherent, but they send to each other reciprocal filaments. The same disposition exists in the plexuses, where there is an intimate communication between all the nerves, by means of the cords and filaments they send to each other. What the plexuses present on a

large scale, is seen on a small in each nerve; and the cords themselves are merely plexuses of nervous filaments. Towards the origin or the central extremity of the nerves, the neurilema is continuous with the pia-mater, but only in that portion of it which constitutes the general envelope of the nerve: the interior sheaths of the nervous filaments become softened and lost insensibly, so that these are naked in the centre of the nerve. The nerves equally are seen to become deprived of their neurilema at their termination, wherever they can be traced far enough. The neurilematic canals do not present in the interior a smooth and polished surface as is the internal surface of vessels; they give out a multitude of prolongations which traverse the medulla of the nerve and sustain it: this last is not free and moveable in the nerve which it owes partly to its consistence, but which is also owing in part to this disposition. There exists cellular tissue about the general sheath, and between the partial sheaths of the nerve, as has been observed with respect to the muscular fascicles and the fibres of which they are composed. In neuralgia, this tissue is sometimes the seat of an œdema and of an infiltration which renders it, in certain cases, compact and close; at other times of a sanguineous congestion or of a very great redness, as Cotugno and others have observed, which leads to the opinion that these painful affections depend on its inflammation. Fat may also accumulate in this tissue. The medullary fibres, contained in the canals of the neurilema, are of the same nature with those of the brain and spinal marrow.

§ 780. The blood vessels of the nerves penetrate between the cords of which they are composed, and divide, for the most part, into two branches, one direct, the other retrograde. Their number is considerable: all the neurilema is perceived to be covered with them in successful injections; they are seen with a lens to spread over even the neurilema of the nervous filaments. This last is formed of fibrous cellular tissue and of blood vessels. No lymphatic vessels of the nerves are known.

§ 781. The structure of the nerves is not exactly the same in all. In the greater part of the researches which have been made on this subject, the optic nerve has been chosen, because

the nervous filaments are larger in it, and that it is easy to fill the neurilematic canals. But, this nerve differs from the others by its canals being separated by common partitions which are detached from the interior of the general sheath. The structure of the nerves has however also been observed in other nerves: it is especially in those of the muscles where the filaments are more distinct than in the nerves of the senses or of the skin, that these observations have been made.

§ 782. Reil, to whom we owe almost all that is known about the structure of the nerves, has well indicated the means by the aid of which this structure may be observed. By washing the nerve with water and nitric acid, at the end of a certain time, the neurilema is entirely destroyed, and there remains medullary filaments which may be seen crossing each other, resting against each other, nearly like the optic nerves in their commissure. On the other hand, plunging a nerve into ley, which may be regarded as an alkaline solution of subcarbonate of soda, the medullary substance is destroyed, and the neurilematic sheaths are obtained. To hinder them from becoming effaced, they may be filled with air: which is very easy, by forcing this fluid into one of them, since they all communicate with each other; the nerve is then tied at its two ends: when dried in this state, it presents, on being cut, a multitude of little canals opening into each other, which gives it the aspect of the interior of a reed. These observations, which have been repeated many times, after Reil, demonstrate the two different substances of which the nerve is composed.

The observations of Home, upon the optic nerve, have shown that the medullary filaments of which it is composed, augment in number, and diminish in volume, from the origin to the termination.

§ 783. The nerves have little or no elasticity; they have no sensible motion, either of oscillation, or vibration, when irritated in the living animal. The irritation of a nerve produces severe pains, and brings convulsive contractions in the muscles.

§ 784. The functions of the nerves are to conduct sensation and motion. They transmit, with incalculable velocity, volition from the nervous centre to the muscles, and convey to

the centre the sensations produced by the impression of external agents. Cutting or tying them interrupts their functions, and renders the parts below insensible and immoveable. Irritation above the interruption produces sensations of pain similar to what the irritation of the extremity of the nerve would have produced. Irritation below the interruption produces contractions, like those which result from the irritation of the origin of the nerve.

785. It has been an object of research, since Herophilus and Galen, whether there were not particular nerves for sensation and others for motion. It was soon perceived that there are sensorial nerves, as the first pair, the second, and the auditory; motory nerves, as the third, the fourth, the sixth, the hypoglossal, &c.; and mixed nerves, as all the spinal nerves which distribute themselves to the skin and muscles of the trunk and members; and as the sub-occipital and trigemini. But the paralyses and anestheses, which have been observed sometimes united, and sometimes separate in the parts of the body to which the nerves with double roots distribute themselves, led to the supposition that these nerves were composed of distinct sensorial and motory filaments. The experiments of Ch. Bell, those of Magendie, and my own, have clearly demonstrated that the posterior roots of the spinal nerves are the sensorial, and the anterior the motory.

§ 786. The nerves are not entirely confined to the functions of simple conductors: they have an activity of their own which manifests itself when they are separated from the nervous centre; but this activity is much augmented by that of the spinal marrow, as that of the spinal marrow is by the influence of the encephalon; so that the cutting off of the encephalon diminishes much the activity of the spinal marrow, and that of the spinal marrow lessens much that of the nerves, and the nearer to a muscle a nerve is cut off, the more the nervous influence upon its contraction is diminished.

§ 787. Have the nerves a power of formation or regeneration such, that on being cut across, their reunion shall have the nervous texture and perform its functions? such even that on being divided with loss of substance, they are reproduced?

These questions have much occupied physiologists, and especially Fontana, Monro, Michaelis, Arnemann, Cruikshank, Haighton, Meyer, &c. Most of these experimenters have resolved in the affirmative the questions relative to nervous reproduction. Arnemann alone, supporting himself like the others upon a series of experiments, has adopted a contrary opinion.

I have made, with one of my pupils,* a great number of experiments in order to resolve these questions. There results from our observations, 1st, that the division of a nerve, produced by a ligature, is constantly followed by the exact reunion of the two ends of the nerve, and by the prompt re-establishment of its functions;

2d. That the imperfect section or the puncture, which has been accused of giving rise, in man, to so serious accidents, does not produce accidents in animals, and that the reunion and the re-establishment of the functions take place very promptly;

3d. That the complete section of a nerve in a part little subject to motion, as for example, along one of the two bones of the fore-arm of a dog, in the neck of the same animal, along one of the bones of the fore-arm in man, &c., is ordinarily followed promptly enough with an exact reunion, and complete re-establishment of the functions;

4th. That in parts much subject to motion, as in the vicinity of an articulation, when a nerve is divided, there takes place, besides the primitive retraction which is constant, an accidental retraction and variable according to the motions of the part. In this case the reunion is long in forming; it is imperfect even if it takes place: the re-establishment of the functions is imperfect also, or even altogether wanting. It is to this that must be referred the results of some of the experiments of Meyer, and the permanent paralysis which is said to result from the section of the radial nerve at the inferior part of the arm;

5th. Finally, that when there is considerable loss of sub-

* L. J. Descot. Dissertation inaug. *sur les affections locales des nerfs*, Paris, 1822.

stance of a nerve, either by excision, or in a contused wound with destruction, there remains a large interval between the two ends of a nerve, and the functions are never re-established, whatever may be the affected nerve; which is sufficient to prove that the anastomoses are of no avail, when the re-establishment of the functions takes place.

We may then conclude that nerves divided reunite; and that when the reunion does not take place, it depends only on the distant separation of the extremities, brought about by the motions of the parts, or by a loss of substance.

§ 788. When a nerve has been divided, there takes place during the first days, about the ends, at their surface, and in their interval, an exudation of organizable matter; the surrounding cellular tissue is penetrated by the same matter, and has lost its permeability. In this state the ends of the nerve are simply agglutinated together, and to the surrounding parts; the functions are still suspended as they were immediately after the division; the two ends of the nerve, which are swollen, especially the superior, the surrounding cellular tissue, and the organizable matter, take more consistence, and become very vascular. In this state, which continues some time, the two ends of the nerve are united by an organized vascular substance; but there is still no communication of nervous action between the two ends. After a time the surrounding cellular tissue ceases to be compact and vascular; the intervening substance, more or less long, according to the kind of wound and the concomitant circumstances, diminishes by degrees in volume, consistence, and redness; takes the appearance and texture of nerve (a texture established by the application made by Meyer of nitric acid to the nervous cicatrix) departing from the extremities to the middle of their interval, and finishes by fulfilling the functions, so much the sooner, and so much the more exactly, as there was no interval between the ends of the nerve, as in the case of ligature, or a very small one, as in the case of simple section, or of a very short excision in a part little subject to motion. On the contrary, when the interval is considerable, the reunion does not take place, or it takes place only by a cellular tissue which does not acquire, at a

certain distance from the extremity, the nervous properties and structure. The time necessary for the complete re-establishment of the structure and functions is not exactly known; it has been certainly exaggerated by those who have advanced that several years are required: it may be estimated at about six weeks or two months.

§ 789. The section of the pneumo-gastric and trisplanchnic nerves united, as they are in the dog, produces constantly death, when it is done on both sides at once. It is upon these nerves that the re-establishment of the functions and the separation of the tissue may be studied simultaneously, according to the experiments of Cruikshank, Haighton, and our own.

The following is what we have seen take place in this section, repeated at different intervals.

Having cut, on the same day, the two pneumo-gastric nrvese in two different dogs, one died thirty hours after the operation, the other more than sixty-six hours after this double section. Another animal, after an interval of nine days between the two sections, died in the night of the fourth and fifth day. In a fourth, the second section having been made at the end of twenty-one days, death took place only on the twenty fifth day, after this second section. Finally, upon another animal, the second section was made thirty-two days after the first, and the animal survived an entire month. At this period, that is to say, two months after the first section, we found the nerve which was first divided, completely reunited. This dog fell under an empyema which developed itself in the left cavity of the chest. Finally, Haighton cut the second pneumo-gastric nerve six weeks after the first, and the animal survived nineteen months, after which time it was killed. It has been pretended that the nervous action, in the same manner as galvanic action, might re-establish itself across a substance different from the nervous tissue, as a fluid or moist cellular tissue; it has been pretended, also, that the nervous action might take place at a distance, and pass over the interval which exists between the ends of the nerve; it has been pretended, finally, that the re-establishment of the functions might take place by anastomosing branches. If it was by the one or the

other of these two first causes that the nervous action had been continued, this action would not have been suspended a single instant, and the animals would not have died in either of the experiments above cited. As to the re-establishment of the nervous functions by anastomoses, it is contradicted by a great number of cases, in which the nerve having been cut in certain subjects, and in others excised or destroyed by cautery, the functions have been re-established in the first instance, and not in the second. The re-establishment by anastomoses is completely proved false by an experiment, which consists in again cutting on the same day, in the place of reunion, the pneumo-gastric nerves cicatrized after previous section of these two nerves at proper times. The animal, which has survived until this moment, dies in the space of one or two days.

It is then, neither by the interposition of a substance simply moist between the two ends of a divided nerve, nor by the action from a distance of the nervous system, nor finally by anastomoses, that the re-establishment of the nervous functions takes place, but by a true nervous cicatrix. We see in effect the functions, at first altogether destroyed, become gradually re-established, and follow, in their re-establishment, all the process of organic union. It can not be denied, however, that the nervous action is propagated to a certain degree, from one part to the other of a divided nerve: this is proved by the experiments of Wilson Philip, which have been repeated in France.*

§ 790. The nerves are subject to other alterations besides those which result from physical injuries; such are inflammation or neuritis, tumours or neuroma. Some consist in a subcutaneous tubercle graniform or pisiform, hard and very painful; others in a schirrous tissue more or less voluminous. Neuralgia and local insensibilities, paralysis and partial convulsions, are the ordinary results of local affections of the nerves; besides, these local affections extend sometimes to the nervous centre, and give rise to general neuroses.

* Vavasseur *de l'influence du système nerveux sur la digestion stomacale;* Paris, 1823.

SECTION III.

ON THE GANGLIONS AND SYMPATHETIC NERVES.

§ 791. *The nervous ganglions* are round or obround bodies, formed of medullary nervous filaments and of a peculiar substance, placed upon the course of the nerves, and especially the nerves of vegetative functions.

§ 792. The name of ganglions, γαγγλιον, was employed by Hippocrates, to designate tumours of the sheaths of the tendons. Galen first applied it to the nodosities of the nerves, from comparison with morbid ganglions. J. Riolen, jr. and Vieussens have made use of the same name; others have employed that of gangliform plexus: that of ganglion is generally used now.

Gall, Reil, Walter, Blainville, &c., have extended the meaning of the word ganglion, and have applied it to the gray substance which exists in the interior of the spinal marrow, to the masses of gray substance which are found in the medulla oblongata and in the crura cerebri and cerebelli, as the corpora olivaria, the corpus rhomboideum of the cerebellum, the optic thalami and the corpora striata; it has been extended even to the olfactory lobes, to the hemispheres of the brain, to the tubercula and to the cerebellum; finally, the ganglions have been confounded with the plexus and with sensorial nervous expansions. These are forced relations, which have already been controverted by Walther the elder, Reimer, and Soemmering. It is not in this sense that the word ganglion is employed here.

§ 793. The ganglions have been described and studied particularly by Meckel,* Jonstone,† Haase,‡ Scarpa,§ Bichat,‖ Weber,¶ and especially Watzer.** The opinion of anato-

* Histoire de l'acad. de Berlin, ann. 1749 & 1753.

† Essays on the use of the ganglions, etc. 1771.—Medical essays, etc. 1795.

‡ *De gangliis nervorum; Lipsiæ*, 1762.

§ *De nervorum Gangliis et plexubus; Mutinæ*, 1779.

‖ *Anatomie Genérale.*

¶ *De systemate nerveo organ.; Lipsiæ*, 1817.

** *De corporis humani Gangliorum fabricâ atque usu. Berolini*, 1817

mists and physiologists on the texture and function of ganglions, may be referred to two principal ones differently modified: some, regarding them simply as condensed plexuses, considor the nerves which depart from them, only as distant divisions of the spinal and cranial nerves; others, considering the ganglions as special nervous centres, consider the nerves which emanate from them as independent of the cerebral system. We shall see that these two opposite systems ought to be combined and mutually modified.

§ 794. The inferior animals, that is to say, the radiata, the mollusca, and the articulata, have nervous enlargements which have been assimilated to the ganglions of the vertebrata. But in the invertebral animals the same nerves belong to all kinds of organs and functions, whilst in the vertebrata the great sympathetic nerves (and to a certain degree, the pneumo-gastric nerves), belong especially to the organs of vegetative functions. Weber has compared the spinal ganglions of the vertebrata to the ganglions of the inferior animals.

In vertebral animals, which alone have true nervous ganglions comparable to those of man, we see these ganglions augment, especially those of the sympathetic nerve, and the pneumo-gastric nerve diminish as the encephalon becomes developed, so that fishes have the smallest sympathetic nerve, and the largest pneumo-gastric, and *vice versa* in the mammalia, as if the vegetative functions ought to be farther removed from the influence of the encephalon, in proportion as this organ is less subject to instinct.

§ 795. The ganglions have been divided into several kinds by those who have described them with the greatest accuracy. Scarpa divides them into simple or spinal, and into compound. Weber divides them into auxiliary ganglions (*de renforcement*,) which are those of the spinal nerves, and some of those of the cranial nerves; and into ganglions of *origin:* these are those of the sympathetic nerve, to which he joins the orbitary and the maxillary. Ribes* divides the ganglions into three

* *Exposé sommaire de quelques recherches anat. phys. et pathol.*, in the Mém. de la soc. méd. d'émulation, vol. viii.

series: he ranges in the first the rachidian or spinal; in the second those which are found in the course of the trisplanchnic; and all that are situated more internally in the third. Wutzer divides them into ganglions of the cerebral system, of the spinal system, and of the vegetative or sympathetic system. I divide them into two kinds: 1st, the ganglions of the encephalo-spinal nerves, some, the most numerous and the most regular, belonging to the nerves with double roots, others placed in the course of the nerves with a single root; 2d, the ganglions of the two sympathetic nerves, some forming a double longitudinal series, and others near the median line.

§ 796. The number of ganglions is very great, as will be seen. They are all situated in the trunk; Lancisi was wrong in stating that they existed in the members. Their size varies from that of an olive to that of a grain of millet; their form is round, oval, lenticular, &c.

§ 797. The ganglions are composed of two internal substances: the first medullary and white; the second pulpy and of a reddish gray. The medullary substance is collected into cords and filaments, like the sensorial and motory nerves. These interior medullary filaments are visibly the continuation of the nerves, connected with the ganglions. The cœliac ganglion is the only one where this continuation is not clearly manifest. These filaments are recognized by their colour and form. The action of alkalies and acids, upon them, renders them manifest, even in the midst of the ganglions, as nervous medullary filaments.

These filaments, on penetrating the ganglions, become deprived of their neurilema, which unites intimately with the exterior membrane of the ganglion. These filaments have their surface less exactly defined than in the nerves; their surface appears more loose, as if blended or intimately united with the adjacent substance. These medullary filaments have otherwise considerable tenacity.

§ 798. The second substance of the ganglions establishes not only the difference between the nerves and ganglions, but between the ganglions and the plexuses. This substance has

been much neglected by anatomists, who, considering the ganglions as plexuses more condensed, have regarded it only as destined to separate or to unite the nervous filaments (Scarpa), or to perform the functions of the cellular tissue (Haase). The matter which surrounds the medullary filaments of the ganglions is a particular cellular tissue, the interstices of which are filled with a mucilaginous or gelatinous pulp, of a reddish ash colour, yellowish in some ganglions. This colour, like that of other organs, does not depend solely on the quantity of blood which they receive.

This secondary substance is not equally abundant, and is not altogether united to the medullary substance in the same manner in all the ganglions.

§ 799. Scarpa says that this pulpy matter is fatty in very fat subjects. Meckel appears to be of the same opinion. Bichat thinks, on the contrary, that the ganglions are never transformed into fat. The observations of Wutzer, and my own, are entirely in union with those of Bichat. In very fat subjects, there accumulates, under the membrane of the ganglions, fat, which, when in great quantity, surrounds not only the ganglion, but compresses it and diminishes its size; notwithstanding it is itself never changed into fat.

§ 800. The ganglions are enveloped by a cellular or fibrous membrane, which differs in the different kinds of ganglions.

§ 801. The blood-vessels of the ganglions are very numerous. The arteries come from the neighbouring trunks; they ramify first in the membrane, where they form a net-work; delicate branches penetrate into the filamentous and pulpy tissue of the ganglion; sometimes arterial branches penetrate into the ganglion with the nervous filaments, and accompany them. The veins offer a similar distribution. Nothing is known concerning the lymphatic vessels of these organs.

§ 802. The medullary filaments present no interruption in the ganglions; they establish a continuity or an uninterrupted connexion between the nervous cords, in the course of which the ganglions are placed. These medullary filaments form connexions in the interior of the ganglion, and traverse them in different directions, in such a manner as to unite together all

the cords which belong to them. From this results the irregular figure and the interior complication of the lateral and median sympathetic ganglions, which are placed in the middle of many nervous cords, and the regular ovoid form, as well as the simply longitudinal direction of the filaments of the spinal ganglions.

§ 803. Bichat tried some chemical experiments on the ganglions, which proved that there was nothing common between their substance and that of the brain. Some anatomists, however, having continued to confound with the ganglions the enlargements of the central nervous mass, composed of white substance and of gray, Wutzer commenced a series of comparative chemical experiments upon the ganglions, and upon the intermixture of the white and gray substances of the brain and cerebellum. It follows from these experiments, that there is a real difference between these two objects; that the ganglions differ from the nerves by a greater proportion of gelatine, and still more from the encephalon by the excess of gelatine, by a greater quantity of albumen, and by a less proportion of fat. Lassaigne* has made a chemical analysis of the guttural ganglions of the horse, and has found them composed, 1st, of fibrine, for the greater part; 2d, of concrete albumen in small quantity; 3d, of soluble albumen; 4th, of traces of fatty matter; 5th, of phosphate and carbonate of lime. Lobstein has observed that although they resist putrefaction longer than the nerves, they become converted promptly into *fat* by immersion in water.

§ 804. The ganglions of the first sort are those which are found in the course and at a small distance from the origin of the nerves of the spinal marrow. There are thirty of them, on each side, which are named spinal; one upon the trigemini nerve, which is called Gasser's ganglion; one or two upon the par vagum, and one upon the glosso-pharyngeal. The spinal ganglions, first observed by Volcher Coiter, to the number of thirty on each side, have an ovoid or olive form. They belong to the posterior root alone of the spinal nerves, the ante-

* Lassaigne, in the Journal de Physiologie, vol. i.

rior is united to the ganglion only by loose cellular tissue. Haase first made this observation, which has since been confirmed by Prochaska and Scarpa. The anatomists who preceded them thought that the two roots of the nerve concurred in the formation of the ganglion.

The membrane of the spinal ganglions, furnished by the dura mater, appears more firm, more dense, and more solid than that of the other ganglions. The ganglion itself is so closely enveloped, that it appears very hard. The pulpy substance envelopes the medullary filaments more loosely than in the others, and is more distinct and more easily separable.

The medullary fasciculi having entered by the posterior or internal extremity of the ganglion, divide into three, four, or five white filaments. They diverge at first from each other, then converge towards the other extremity. These filaments unite with each other, so that each departing cord is formed of filaments which probably come from several entering cords. However, the number, the tenuity, and the confusion of the filaments are not very great. The spinal ganglions have a simple texture compared with the others.

The nervous fasciculi, collected together after leaving the ganglion, unite intimately, at the distance of hardly two lines, with those of the anterior root, to form the common trunk of the spinal nerves: a trunk which itself has only a length of one or two lines before dividing into the anterior and posterior branches.

The common trunk of each spinal nerve, at a little distance from the ganglion, furnishes a simple branch, often double, rarely triple, which goes towards the ganglion near the sympathetic nervous trunk, and joins it in such a manner as to establish the most intimate connexion between the nerves of the spinal marrow, the spinal marrow itself, and the great sympathetic nerve. Anatomists, and especially physiologists, have frequently discussed the question, whether the branch of communication comes from this or the other root. I have seen, as well as Scarpa and Wutzer, that the simple or double branch comes from the common inextricable trunk, and that, when it can be traced, it is found to come from both roots.

This communicating branch, similar at its origin, to the spinal nerves, having arrived at about a line from the ganglions of the sympathetic nerve, reddens and takes successively the characters of this nerve.

The ganglion of the fifth pair of nerves, or Gasser's ganglion, belongs evidently to the series of spinal ganglions, from which it differs only in form. The white nervous fasciculi which pass beneath, without forming a part of it, that Paletta proposed to consider as particular nerves, resemble entirely the anterior root of the spinal nerves.

The ganglions of the par vagum and of the glosso-phargugeal nerve resemble as yet, in their form and texture, the spinal ganglions.

The trunk even of the par vagum has a texture altogether peculiar and different from the other nerves, without resulting however from a linear series of ganglions, as Reil says. It greatly resembles the trunk of the sympathetic nerve.

§ 805. The second sort of ganglions comprehends the series of three cervical ganglions, of twelve thoracic, of five lumbar, and of four sacral, belonging on each side to the trunk of the sympathetic nerve. The opthalmic ganglions, spheno-palatine, and maxillary, are also of the same sort. The cardiac ganglion, often replaced by a plexus, must be joined with them, as well as the semi-lunar or cœliac ganglions, and many others placed in the solar plexus and its divisions; the little coccygeal ganglion, which is found sometimes at the union of the two sympathetic nerves, opposite the summit of the sacrum; and the little palatine ganglion, which exists sometimes in the anterior palatine foramen; finally some variable ganglions are also added, which are sometimes found upon the coats of the arteries, where they replace the plexuses, as the ganglion of the anterior communicating artery of the brain, that of the cavernous sinus, that of the deep seated temporal artery, &c.

All these ganglions have in general an irregular and variable figure; they have in general connexions with several nervous trunks or branches. The direction of the medullary filaments which traverse them is very complicated, and rarely thin fila-

ments traverse them simply from one side to the other. The pulpy substance of these ganglions is so strongly united with the medullary filaments, that it is very difficult to separate them. This substance, besides, appears to differ from that of the other ganglions: it is harder, more close, and more tenacious. This is especially remarkable in the cœliac ganglions and in those of their plexuses. The membrane of the ganglions of this series is cellular and firm, but has not the fibrous solidity of that of the spinal ganglions.

§ 806. The cords and the nervous branches, in a word, the nerves which unite these ganglions, greatly differ from those which are immediately derived from the spinal narrow. Instead of diminishing like these last, in proportion as they depart from their origin, or from their central extremity they furnish successive divisions, we see them indifferently diminish or increase, or not change their size in departing from the ganglions. The ganglionary nerves have less power of cohesion and more fragility than the others. The external envelope of the ganglions continues upon the nerves to a certain distance; beyond the point where this communication ceases to be apparent, the neurilema appears thinner and more intimately united with the medullary substance than in the other nerves. Their internal substance results, like that of the ganglions, from medullary filaments, and pulpy, gray and reddish substance, that can be hardly separated from them; the filaments, or the branches united to form a cord, are themselves hardly separable; the ganglionary nerves, finally, seem to be formed of the same substances as the ganglions, these being only elongated into cords. However, the nerves of the ganglions are not all absolutely similar: those which unite the spinal ganglions to those of the sympathetic nerve, and the splanchnic nerves, which go from the thoracic ganglions of the sympathetic to the cœliac ganglions, seem intermediate, by their white colour, their cylindrical form, their fibrous composition, their firmness and tenacity, between the nerves of the spinal marrow and the reddish gray, flattened, irregular, pulpy, soft and fragile nerves of the sympathetic. Scarpa pretends that the sympathetic nerves may be analyzed by anatomy, and reduced into filaments like the others. I think

that this is impossible, especially in the nerves which form the mesenteric or intestinal plexuses.

§ 807. *The sympathetic nerve*,* intercostal or trisplanchnic, is a nervous and ganglionary cord, extended from the head to the pelvis, connected, by anastomosing branches or roots, with all the spinal nerves and the trigemini, and furnishing numerous branches to the organs of the splanchnic cavities of the trunk.

The cephalic extremity of this nerve penetrates into the cranium by the carotid canal and the cavernous sinus, where it forms a plexus and often a ganglion upon the carotid artery; it sends hence anastomosing filaments to the nerve of the sixth pair, and communicates with the inferior filament of the vidian; it sends secondary plexuses upon the branches of the internal carotid artery, and may be traced to a little solitary ganglion placed upon the anterior communicating artery of the brain.

It consists then of three cervical ganglions, twelve thoracic, five lumbar and four sacral, and of their cords of communication placed on each side of the anterior face of the vertebral column.

Throughout the whole length of the nerve, each ganglion presents external anastomosing filaments or roots, and internal filaments or branches.

In this respect, the sympathetic nerve may be compared to a subterraneous stem, or an articulated rhizoma, which, at each joint, presents on one side roots, and on the other branches, both of which depart at right angles, or at least at a very large angle.

The branches of the great sympathetic distribute themselves to the organs situated in the face, neck, breast, the abdomen properly so called, and in the pelvis.

The pelvic extremity of the sympathetic nerve consists of a

* Walter, *tabulæ nervorum thoracis et abdominis*. Berol. 1783.—H. A. Wrisberg, *de nervis arterias venasque comitantibus.—De Nervis pharyngeis.—De Ganglio plexuque similunari.—De Nervis viscerum abdominalium, etc., in Comment.* Gotting.—Chaussier, *Table synoptique du nerf trisplanchnique*.—Lobstein, *De nervi sympathetici humani fabrica, usu et morbis*. Paris, 1823-4, cum tabulis.

little ganglion or arch, in which the two nerves unite, and which furnish some delicate filaments to the environs of the anus.

The internal branches of the sympathetic nerve are distributed, some directly upon the arteries, and form plexuses, the others, in much greater number, reach the median line, and form there, in uniting to those of the opposite side, median plexuses or ganglions (the cardiac and cœliac), which communicate with the branches of the pneumo-gastric nerve, which furnish secondary plexuses or ganglions, and terminate in the heart, the aorta, the digestive canal, the urinary and genital organs, but especially in the arteries of these organs.

§ 808. Rare interruptions, and perhaps not well observed, in the trunk of the sympathetic nerve, have induced some anatomists to regard the existence of this trunk as a circumstance of little importance. There is exaggeration in this opinion. However, its roots are very certainly in the spinal nerves, and not in the vidian nerve and the sixth pair.

The branches of the sympathetic nerve, differ not only from those of the other nerves, but they differ very much from each other: each ganglion and especially each plexus of branches has its proper or peculiar character.

The sympathetic nerve has been considered, by Sœmmering especially, as the nerve of the arteries: in truth the arteries receive many branches from it; but the muscular tissue of the heart, that of the digestive canal, the mucous membrane of this canal and the urinary and genital passages, the ligaments, the bones even of the vertebral column, receive filaments from it. It is remarkable that the veins, the lymphatic vessels and glands are deprived of them, as well as the serous membranes. They are found, on the contrary, in the long muscles of the neck, in the intercostals, and the diaphragm.

§ 809. The spinal ganglions with their nerves, are the first parts of the nervous system that are visible.

The ganglions and the nervous trunk of the trisplanchnic are apparent in the fœtus after the third month. The cœliac ganglions and the splanchnic nerves, which are in a manner their roots, develope themselves a little less quickly than the

cervical ganglions and the cardiac nerves. In old age the ganglions are paler and drier than in the adult age.

The ganglions and cords of the sympathetic nerves are found in fœtuses deprived of brain, and in those which are deprived of brain and spinal marrow.

§ 810. The vertebrate* animals alone have a particular nervous system for the organs of vegetative functions.

In fishes the sympathetic nerve consists of a very fine thread, with few or no ganglions.

In reptiles it is more distinct: it unites together the intervertebral nerves, and penetrates into the cranium united with the par vagum.

In birds it penetrates into the cranium with the par vagum and the glosso-pharyngeal; it communicates with the fifth and sixth pairs; it presents in the neck an apparent interruption, arising from its being contained in the vertebral canal: it is very distinct and ganglionary in the thorax, and is prolonged even unto the caudal vertebræ.

In the mammalia the sympathetic nerve does not differ much from that of man.

Meckel and Weber have remarked that the sympathetic nerve is so much the smaller, relative to the body, as the animal is farther removed from man. A second general observation is that the sympathetic nerve and the par vagum are in an inverse relation with respect to their development; so that they mutually supply the place of each other, in the vegetative life to which they both belong. It is necessary also to remark, that the sympathetic nerve is developed in all animals in proportion to their circulatory apparatus, to which it in great part belongs.

§ 812. The ganglionary nervous system, which exists in all animals, which, in the vertebrata, forms a system apart, in connexion with the nervous centre whose development it precedes; which preserves on one part the state of dissemination that the nervous system of the invertebrata presents, and which forms also some principal centres, as the cardiac plexus,

* Weber, *Anatomia compar. nervi sympath.;* Lips., 1817.

and especially the ganglions, and the cœliac or solar plexus, which has been called the abdominal or epigastric brain, should have a great importance in the organization. But before explaining the functions of the sympathetic nerve, it is necessary to examine that of the ganglions.

§ 813. Willis had, with respect to the ganglions and sympathetic nerve, an idea similar enough to that which now prevails: he considered the ganglions as the diverticula of the spirits, and the sympathetic nerve as placed between the cerebral conceptions and the precordial affections, between the actions and the passions, in such a manner as to establish a consent between the parts.

Vieussens considers also the intercostal nerve as a sympathetic medium between the brain and the viscera of the two other cavities; he places in the ganglions, which he calls plexuses, a centre of muscular and fermentative action. Lancisi also regarded the ganglions as centres of impulse which he compared to the heart.

Winslow, who first employed the name of sympathetic nerve, regarded the ganglions as centres of origin, true little brains.

Meckel attributed to the ganglions the use, 1st, of dividing the nervous branches into lesser ramifications, and these into filaments; 2d, of making the branches depart in different directions to distant places; 3d, of uniting several branches into a single cord.

Zinn holds the same opinion, adding that the branches from different points uniting in a ganglion, are more intimately mixed than in a plexus.

Johnstone regarded the ganglions as brains capable of developing and communicating the nervous power, as the origin of the involuntary nerves, and as proper to break the influence of the will upon the organs of involuntary motion, such as the heart.

Haase, who has assimilated the ganglions to the plexus, has controverted the opinion of Johnstone with these two arguments: that the voluntary muscles receive nerves from the spi-

nal ganglions, and that the involuntary organs, as the stomach, receive them from the par vagum.

Scarpa adopts an opinion similar to that of Meckel and Zinn: according to him the use of the ganglions is to mix and to unite anew the nervous filaments; according to him the nerves of the viscera emanate directly from the spinal nerves, and from the fifth and sixth pairs, and are only collected together in the ganglions.

All these opinions, as we see, may be referred to two. Some as Meckel, Zinn, Haase, Scarpa, and more recently, Legallois, have seen in the ganglions, only a particular arrangement, an anatomical disposition of the nervous filaments; the others, as Winslow, Johnstone, Lecat, Petit, Metzger, &c., have regarded the ganglions as points of origin, and especially as centres of nervous action. No one has defended this last idea with more warmth and talent than Bichat. Reil, Autenreith, Wutzer, Broussais, and many others, have added new arguments to those of our celebrated author, whose opinion they have nearly embraced.

§ 814. Bichat regards the organic nervous system as resulting essentially from numerous centres or from ganglions united together by filaments, and the sympathetic nervous trunk itself as a series of ganglions and anastomosing filaments. Bichat has perhaps given to ganglions an exaggerated importance; but certainly he has not granted to their ensemble, their reunion, all the importance which it merits.

According to Reil, the sympathetic nerve constitutes a peculiar system, which he calls ganglionary system; he calls it also the vegetative nervous system. In the vertebrate animals it is united to the cerebral or animal system, but it does not emanate from it. This system, instead of having a single centre where the roots are implanted, has several foci of action: 1st. It consists of plexuses or net work placed around the arteries, about twelve in number; among them, a principal one, the epigastric, furnished with ganglions, and forming secondary plexuses, is a sort of centre or brain. 2d. These plexuses are connected with the cerebro-spinal system by branches and conducting plexuses; the two trunks united below, before the

coccix, and above by the fifth and sixth pairs and by the brain, constitute an elliptic periphery which embraces all the system of ganglions and plexuses, and into which several cerebral nerves penetrate, particularly the eight pair. 3d. The branches or conducting plexuses would transmit sensation and volition, if they were perfect conductors; but they may be considered as semi-conductors, and the ganglions as isolating bodies.

There results from this two nervous systems and two spheres of nervous activity: 1st, the animal sphere, in which the impressions are perceived, where the volitions determine motion; 2d, the vegetative sphere, where the nervous activity is distributed slowly, continually, and obscurely. In this system, the impressions determine motion, without being propagated to the animal centre. In the state of disease, however, the communicating cords and plexuses become conductors, the ganglions cease to be isolating, the impressions are perceived, and the motions are influenced by the animal centre.

According to Reil also, in the magnetic sleep, the separation of the two nervous centres disappears, and the epigastric nervous centre, the centre of the vegetative sphere, becomes a distinct sense.

Autenreith considers the sympathetic nerve as arising from the brain and spinal marrow, but becoming more and more independent in proportion as it is separated by plexuses and ganglions, the reddish or grayish substance of the sympathetic nerves conducting impressions and irritations with more difficulty than the white.

Weber has collected together many anatomical and physiological arguments, to demonstrate that the sympathetic nerve constitutes a particular system, which, independent of the brain, has its centre within itself.

Wutzer has observed, as well as Bichat and others, that the mechanical irritation of the sympathetic nerve does not produce any appreciable effect; whilst a more powerful irritant, as galvanism, determines pains and convulsions.

Broussais considers also the intercostal nerve as a peculiar system, a particular sensitive centre, which transmits impressions to the animal sensorium, and consequently determina-

tions to the voluntary muscles. In the fœtus it acts alone, directs the secretory and nutritive organs, excites the energy of the heart, extends its action to the animal centre, and determines automatic movements. In anencephalous and *amyeles* fœtuses, it excites muscular movements by its action upon the spinal nerves. After birth, it acts upon the nervous centre, transmitting to it the internal sensations, and establishes thus, between the brain and the viscera of the two other cavities, a connexion fertile in phenomena. At all times it rules the action of the capillary vessels, and directs nutrition through the intermedium of the formative or plastic power, which this ingenious writer calls *vital chemistry.*

§ 815. Almost all these opinions, which consist in considering the system of ganglions as an independent system, err in being too absolute, as well as those which consider in the ganglions only a purely anatomical arrangement. The system of ganglions ought to be considered at the same time as a system separate or united, independent or dependent, according to different circumstances for the most part already indicated.

The functions of the ganglions appear to be to *diminish* or to *arrest* the influence of the nervous centre upon the ganglionary nerves, to *diminish* or to *hinder* the transmission of impressions to the centre; so that by the action of the ganglions, the vegetative nervous system is *separated* from the animal system.

The ganglions appear besides to *collect*, to *coerce* the nervous power which they draw from the spinal marrow, to develope it by themselves, to communicate it conveniently to the nerves and to the organs where they terminate.

The ganglions exercise *different* functions according to the *diversity* of their texture.

These differences consist in, 1st, the mixture more or less intimate of the medullary fibres; 2d, the diversity of the secondary substance; 3d, the differences in the exterior membrane, more or less compact, more or less tense; but, it is in the ganglions of the sympathetic nerve that we observe the greatest intricacy and blending of the medullary filaments, the tenacity and most intimate union of the secondary sub-

stance, and a membrane or capsule tolerably firm and very adherent to the interior substance. In the spinal ganglions, on the contrary, the medullary filaments are straight, unmixed, and the secondary substance is coarse, loose, and very distinct from the filaments: these ganglions also are regarded as less perfect than the others; Pfeffinger also thinks that they ought to be excluded from this class of organs. The function of these last ganglions remains otherwise very doubtful. It does not appear, in effect, that they diminish the nervous communication; neither can they be considered as the origins of the common motory and sensitive nerves, for the anterior root of the spinal nerves is distinct from them.

§ 816. The uses of the ganglionary nervous cords are to conduct the nervous influence; but they are conductors, a little different from the other nerves, from which they differ by approximating to the ganglions: they are imperfect conductors. Mechanical or chemical irritations do not traverse them; but galvanic irritation is conducted by them, and determines either sensations or contractions. It is the same with morbid irritations, as irritations of the intestines, ureters, &c. which are perceived.

The functions of the sympathetic nerve are to direct nutrition and the secretions; to distribute the nervous agent to the heart, the digestive canal, and the urinary and genital organs; to establish a sympathetic connexion between all the principal organs. It fulfils these different functions without the influence of the will and without consciousness of impressions, the ganglions performing at the same time the office of slight ligatures, which moderate the transmission of the nervous influence, and of particular centres of activity, which augment and modify its distribution.

This nerve forms thus a particular system in the general system; it has a sphere of peculiar action enclosed within the general sphere. Both nervous systems have intimate connexions; they influence each other reciprocally, especially in a morbid state.

§ 817. Lobstein has collected several very curious facts relative to the morbid alterations of the ganglions and sympathet-

ic nerves: he has observed the inflammation of the semi-lunar or cœliac ganglions, in cases of chronic abdominal neuropathy, hooping-cough, and tetanus; he has also observed in several cases the inflammation of the cardiac and pulmonary nerves. Autenreith has also observed in hooping-cough the inflammation of the par vagum, sympathetic, and cardiac. Duncan has seen in a case of diabetes the abdominal portion of the sympathetic nerve three or four times larger than usual.

The sympathetic nerves are, like the others, augmented in volume in hypertrophies, diminished, on the contrary, in simple atrophies, as well as in those which result from an accidental production infiltrated into the tissue of an organ.

Many abdominal and thoracic diseases seem besides to depend on an irregular action of the sympathetic nerve; and others, very numerous also, on the anormal action of this nerve upon the cerebral nervous centre.

CHAPTER XI.

OF ACCIDENTAL PRODUCTIONS.

§ 818. The productions which occur accidentally in the human organization are humours, concretions, tissues, and living animals.

These objects do not form a part of the healthy or regular organization: they belong only to morbid anatomy. Their description, or at least their summary indication, here has for its object to complete what has been said, under the head of each tissue in particular, upon the alterations and productions which are peculiar to it. The productions which are under consideration in this chapter, are common to several parts or to the totality of the organization.

The knowledge of the accidental productions and alterations is very important to the pathological anatomist; for, on the one hand, this knowledge is the basis of pathology; and on the other hand, anatomy being rarely studied upon healthy subjects, but generally upon the bodies of diseased individuals, the anatomist meets at every instant, in his researches, with alterations of organization and accidental productions.

SECTION I.

OF ACCIDENTAL HUMOURS.

§ 819. The natural humours may be altered in their quantity or quality; some of these alterations have been indicated. We sometimes find besides humours altogether different from

the first. Among these, pus is the only one which is sufficiently well known to be described.

§ 820. *Pus** is an accidental humour resulting from a morbid secretion, which is called suppuration. Pus is composed of microscopic globules, similar to those of the blood, discovered by Home, floating in a fluid coagulable by the solution of muriate of ammonia.

It is of a white or yellowish colour, opake, and of the consistence of cream. Its consistence and its colour depend upon the proportion of globules to the fluid part. It is heavier than water. It has a taste slightly saline, constant, and a peculiar weak odour, a little variable.

Pus sinks in water, while mucus floats. By agitation pus becomes diluted, mixes with the water, and whitens it uniformly; mucus, on the contrary, remains in distinct flocculi. Pus coagulates by heat, acids, and alcohol; alkalies render it viscous, thready, and dissolve it. It is composed, according to Schwilgué, of albumen in a particular state, of extractive matter, of a fatty matter, of soda, of muriate of soda, of phosphate of lime, and of other salts. It resembles much the serum of the blood, from which it appears to differ only by the state of the albumen and of the extractive matter. Mucus becomes diluted in water, dissolves by the addition of sulphuric acid, while pus does not. A solution of caustic alkali dissolves at the same time pus and mucus, and by the addition of water the pus is precipitated alone. These chemical characters, and others of the same kind, are not as certain as the action of water alone, and especially as microscopic observation.

* C. Darwin, Experiments establishing the criterion between mucaginous and purulent matter; Lightfield, 1780.—Brugmans, *Dissertatio de pyogeniâ;* Groningæ, 1785.—E. Home, on the properties of pus; London, 1789.—Grasmeyer, *Abhandlung von dem eiter, &c.;* Gotting, 1790.—Schwilgué, *Mémoire inédit sur le pus, analysé dans la Nosogr. Philos.*, vol. ii.—G. Pearson, on expectorated matter; in Phil. Trans., 1809.—Idem, Observations and experiments on pus; ibid., 1810.—Rizetti, *De phthisi pulmonali specim. chim. med.;* in Mém. de Turin, vol. ii. et iii.—Rossi and Michelotti, *Analyse première du pus;* ibid., vol. iii.—E. Home, On the conversion of pus into granulations or new flesh; in Phil. Trans., 1819.

Pus does not always present precisely the same physical qualities and the same chemical properties. It can be distinguished into creamy pus, homogeneous, commonly called most laudable; into serous pus, sanious, or purulent serosity; into glareous pus or puriform mucus; into curdled or clotted pus; into concrete or plastic pus. Besides, pus may be mixed with blood, serosity, excrementitious matters, putrid matter, accidental tissues, calculi, virulent matter, &c.

In all these cases it is composed, according to Pearson, of a white, opaque, and slightly soluble animal oxide, of a limpid fluid, analogous to the serum of the blood, which holds the animal oxide in suspension, but not in a state of solution; and of an innumerable quantity of microscopic globules. The differences which it presents depend on the different proportions in which these essential materials are found, as well as the substances which may be found there accidentally.

§ 821. Pus may be formed in the greater part of the organs. The tissue in which suppuration is most frequent and seems the most easy, is the mucous membrane. Some hours after the application of an irritating cause, the physical and chemical properties of mucus are seen to change insensibly into those of pus. When the irritation diminishes and ceases, the properties of pus are seen to change inversely into mucus. The suppuration of the mucous membrane is accompanied with a slight degree of redness and swelling, and very rarely with ulceration.

The skin suppurates easily whenever it is irritated and the epidermis removed. This may continue indefinitely, if the irritation is continued, or frequently renewed; the skin then takes on the aspect of an inflamed mucous membrane.

The cellular tissue being exposed by the removal of the skin, the hemorrhage stops; then flows serosity, which by degrees takes the character of pus. At the same time the wounded surface covers itself with a layer of organizable matter, which becomes vascular and covered with granulations.

The cellular tissue being irritated by a foreign body or by an unknown cause (*spina helmontii*) inflames; pus forms in the centre of the phlegmon: this pus is enclosed in a mem-

brane of a new formation, more or less distinct, more or less vascular, according to its age; the surrounding cellular tissue, inflamed and very vascular, has lost its permeability by the interstitial deposition of organizable matter.

The serous membranes, when they suppurate, present analogous changes; they become very vascular and take at length the appearance of mucous membranes.

§ 822. Boerhaave attributed the origin of pus to the meeting of inflamed organs; Pringle and Gaber attributed it to a change in the serum of the blood; these two opinions, differently modified and combined, have been for a long time and generally adopted.

The idea that pus is formed in vessels, and that it departs from them by a secretory action of these organs, was first indicated by Dr. Sympson, then by Dehaen, and afterwards by Dr. Morgan, of Philadelphia. Hunter and Brugmans have embraced and developed this doctrine, which is now generally adopted.

Suppuration is a morbid secretion. This secretion is always preceded and determined by inflammation; but the inflammation is more or less evident. Dehaen himself, who expressly admits suppuration without previous inflammation, evidently means to speak only of inflammation with ulceration: in fact, we now well know, what he then announced, that suppuration might take place upon surfaces without alteration; he notices, in cases of suppuration without inflammation, plastic productions and adherences which depend, as we know, on inflammation.

In scrofulous constitutions suppuration is often preceded only by a chronic and latent inflammation, but which does not the less exist, although it is obscure.

§ 823. Suppuration, when it exists for a long time, and when it takes place on a large surface, becomes, by its association with the functions, an important secretion; thus we should not lightly establish or suppress a suppuration.

Pus is sometimes the vehicle of virus introduced into the organization; it is considered also, in some cases, as the vehicle of the cause of maladies eliminated by the organization.

According to Sir Ev. Home, pus has for its use to furnish, by its coagulation on the surface of suppurating wounds, the materials of the cicatrix, that is to say, the organizable matter of this new tegument.

SECTION II.

OF STONY CONCRETIONS.

§ 824. Concretions or calculi* are solid bodies, more or less hard, which form in the humours contained in the cavities, the reservoirs, and the ducts lined with the mucous membrane. This formation is always accompanied by a change of composition more or less evident of the fluids where it takes place.

§ 825. Intestinal calculi are rare in the human species. These calculi, more or less voluminous and numerous, are round or ovoid, yellow or brown: their specific gravity is 1.4. Their nucleus is a biliary calculus, hardened fæces, or a foreign body. They are formed of layers, and composed of earthy substance, especially phosphate of lime, and a little animal substance.

The mucous and sebaceous follicles contain sometimes indurated or more or less concrete masses.

Several instances have been cited of little calculi of phosphate of lime and animal matter, in the caruncula lachrymalis, in the tonsils, and in the prostate.

Stony concretions of the same nature have been found sometimes in the lachrymal canal and sac, in the salivary glands and their ducts, and in the pancreas.

§ 826. The biliary passages† are frequently the seat of cal-

* Walter, *de concrementis terrestribus.* Berol., 1775.—Vicq. d'Azyr, *Academ. roy. de medicine,* ann. 1779.—Mosovius, *Dissert. de calculorem animalium, corumque imprimis biliariorum origine et natura.* Berolini, 1812.

† Sœmmering, *de Concrementis biliariis corp. humani.* Traject. ad Mœn., 1795.—Thenard, *Mém. de la Soc. d'Arcueil,* vol. i.

culi, *cholelithi.* They are found most often in the gall bladder; sometimes in the ductus choledochus or the cystic, or hepatic ducts; or in the intestinal canal, and rarely in the roots of the hepatic canal within the liver. The number and size of these calculi vary extremely: from one to several thousand have been found in the same gall bladder, from the size of a pullet's egg to that of a millet seed; their colour varies from white to yellow, brown, and black; their surface is rounded or polyhedral, polished or rugose; their consistence varies much; their specific gravity is from 0.20 to 0.35. They are divided, according to Walter, into three kinds: striated or radiated, *striati*, lamellated, *lamellati*, and provided with a rind, *cordicati*. In the human species these calculi are formed of cholesterine, of the yellow matter of the bile, and sometimes of a little picromel.

Urinary calculi,* *urolithi*, are found in the pelvis of the kidney, in the ureter, in the mouth of this canal, in the bladder, in the urethra, in the prepuce, in the loculi of the bladder, in the ducts of the prostate, and in accidental urinary cavities and passages.

The calculi of the pelvis and calices of the kidney, mould themselves in these cavities, when they increase in this place and become ramose like a branch of coral.

Calculi of the bladder are the most common; sometimes, and it is so ordinarily, there is only one in the bladder, sometimes there are several; more than a hundred have been seen. Their size and their weight vary from that of a grain of wheat to that of an infant's head, and to more than six pounds in weight. Their form is round, obround, tetrahedral, cuneiform, or cubic, &c.

Their surface is smooth, rugose, or mamillary; their colour and consistence are very variable. They have always a nucleus, formed, either of a gravel stone descended from the pelvis of the kidney, a clot of blood, a flocculus of mucus, or a foreign body.

* Fourcroy et Vauquelin, *Mém. de l'inst. Nat.*, tom. iv.—Wollaston, *Philos. Trans.*, ann. 1797, &c.

They are sometimes homogeneous, frequently formed of superimposed layers, similar or different; at other times mixed or heterogeneous, and without layers.

The calculi of the bladder are composed: 1st, of uric acid; 2d, of cystic oxide; 3d, of phosphate of lime; 4th, of urate of ammonia; 5th, of ammoniaco-magnesian phosphate; 6th, of oxalate of lime; 7th, of silex; 8th, of carbonate of lime; 9th, of xanthic oxide; 10th, of fibrinous matter; 11th, of mucus; and 12th, of phosphate of iron, and magnesia, of carbonate of magnesia, and urate of soda. These substances are found in calculi, either isolated or combined by two, three, four, and five. The most common of all is the calculus of uric acid; then the fusible calculus, composed of the ammoniaco-magnesian and calcareous phosphates; then the mural calculus, composed of oxalate of lime; then the calculus formed of distinct layers of uric acid and of oxalate of lime, &c. Silex and the cystic oxide, and still more the xanthic oxide and fibrine, are the rarest substances in urinary calculi.

§ 828. It is said that pisiform calculous concretions have been found in the spermatic vesicles and ejaculatory ducts.

Similar little concretions are sometimes found also in the fallopian tubes. As to concretions in the uterus, these are for the most part ossified fibrous bodies. However, concretions of phosphate of lime have been found in this organ having a foreign body for a nucleus.

We are assured that calculous concretions have been found in the excretory ducts of the nipple.

SECTION III.

OF ACCIDENTAL TISSUES.

§ 829. Accidental tissues* are new organs developed in the living body.

* Laennec, *Cours oral de mêdecine, au Collége de France, année* 1820-1823.

These tissues may be divided into two kinds: 1st, tissues analogous to those of the healthy organization;

2d. Heterologous tissues or tissues without analogy in the regular organization.

There are also some accidental tissues, intermediate, so to speak, between the one and the other, analogous, if not with any thing in the human organization, at least with that of other animals.

§ 830. These different kinds of tissues are sometimes isolated, at others, and frequently, united or combined with each other. They are even often united with accidental humours, with living animals, with altered humours or tissues, &c.

§ 831. Among anatomists and pathologists, some (Dupuytren, Cruveilhier, &c.) regard accidental tissues as the result of transformations experienced by the natural tissues: they call the analogous accidental tissues, transformations properly so called, and heterologous tissues, degenerations; others (J. Hunter, Abernethy, Laennec, &c.) regard them as new or epigenetic productions. It is a question very difficult to resolve; however, the last opinion appears to us the most conformable to observation.

§ 832. True transformations are very rare, and take place only between nearly similar tissues: thus the cartilages of the larynx change into bone; the mucous membrane exposed to the air changes into skin, as the skin drawn into the interior, by a cicatrix, becomes mucous membrane, &c. It is thus that we see, in trees, roots change into branches, and reciprocally branches into roots. But most of the pretended transformations are only productions: thus a cicatrix is a membrane entirely new, and not the result of the transformation of denuded tissues; thus cancer of the neck of the uterus, is the result of a substance of new formation infiltrated into its tissue, which has separated, compressed it, and brought on atrophy, and not the result of a degeneration of this tissue.

ARTICLE I.

OF ANALOGOUS ACCIDENTAL TISSUES.

§ 833. These tissues resemble more or less perfectly the tissues of the healthy man.

They are alterable like the natural tissues, and even more so.

These tissues are of two sorts: 1st, some are the result of the adhesion of the lips, of a solution of continuity, or of regeneration after a loss of substance; 2d, the others are a result of a production altogether accidental. Both have been described under the head of each tissue (*Chap.* i *to* x).

§ 834. The demi-analogous tissues are, 1st, some of the above tissues, which do not attain a perfect degree of organization: such are especially cicatrices or accidental cutaneous productions, the production of the white compact and flaccid tissue, demi-cartilaginous productions, earthy and stony ossifications, imperfect corneous productions, &c.; 2d, there are also the pearly production, analogous to the natatory bladder of fishes, observed in the walls of cysts; the production of fungus in laminæ, etc.

ARTICLE II.

OF HETEROLOGOUS ACCIDENTAL TISSUES.

§ 835. Heterologous accidental tissues, morbid, or without analogy in the healthy organization, are numerous. The most common and best characterized are, tubercles, schirrus, the encephaloid tumours and melanosis; some others of more rare occurrence will be indicated hereafter.

§ 836. These tissues commence probably in the fluid state; but from the moment they are perceptible they are solid. They remain for a greater or less time in this state, which is called that of crudity or of organization; a state in which they may be compared to zoophytes, in which they present, for the most part, vessels, and are injurious only mechanically. They afterwards soften, decompose and liquify. In this state, which

Bayle compares to an anticipated death, they cause pains more or less sharp, and sometimes none; they irritate and inflame the neighbouring parts; they exercise a deleterious action upon the organization, and particularly upon nutrition, even upon that of the bones; they extend and multiply then more or less rapidly in the organization.

The origin and cause of these tissues are unknown. They have been regarded as innate or hereditary; as resulting from an aberration of the formative action; as organized beings developing and dying prematurely in the midst of the organization; as products, results of inflammation and irritation, &c. These are so many hypotheses more or less ingenious and more or less well founded.

These tissues exist under the form of isolated masses, of enveloped masses, of infiltrations in the tissue of organs, &c.

Sometimes they exist separately, sometimes combined with each other and with other accidental productions, and with altered tissues and humours.

I. OF TUBERCLES.

§ 837. The tubercle, or tubercles, for they exist almost always in great numbers, constitute the most common morbid tissue. They are called also scrofulous tubercles, because they are met with in most cases of scrofula.

This tissue exists under the form of isolated or enveloped masses, and under that of infiltration.

It commences by the gelatiniform state; but this state is perceivable only when the tuberculous substance is infiltrated.

It afterwards enters into the grayish, transparent, as if demi-cartilaginous state: this is the first distinct period of isolated tubercles; they constitute the miliary granulations of Bayle.

These grains in enlarging, often unite in a mass; they become opaque, yellowish, friable, commencing by the centre. The same change of colour and consistence takes place in the state of infiltration; it is yet the state of crudity.

They afterwards soften and liquefy: at this period, or even in the preceding periods, there is produced much new tuberculous substance, either in mass, or by infiltration.

The tuberculous matter, softened more or less completely, into homogeneous pus, or into clotted pus, is evacuated by an opening in the skin or mucous membrane; it is perhaps also sometimes re-absorbed. Sometimes the collection remains inflamed, ulcerated indefinitely; at others it contracts and becomes obliterated; sometimes the membrane of new formation which lines it acquires a demi-mucous or demi-cartilaginous texture, and constitutes a permanent dry fistula; at others, finally, a friable matter only is found, probably the residue of a re-absorption, the tubercle not having formed an abscess.

Vessels are never found in tuberculous masses: in the case of tuberculous infiltration, the vessels being compressed and obliterated, shortly disappear. The masses which are developed slowly have a soft or glutinous, cellular, cartilaginous, and sometimes even osseous envelope.

The tuberculous tissue is found in all the organs, and especially in the lungs; in the natural and accidental cellular tissue, at the surface of serous membranes, but especially in their false membranes, at the free surface of the mucous membrane, and especially that of the intestine, in the lymphatic ganglions, in the glands, in the spleen, in the bones, in the muscular tissue, in that of the heart, in the encephalon and in the spinal marrow, and in compound tumours.

This morbid tissue has been observed in all vertebrate animals.

II. OF THE ENCEPHALOID TUMOUR.

§ 838. The encephaloid or cerebriform tissue is a very common morbid production: it has been confounded under the name of cancer with several others, and especially with schirrus. Bayle and Laennec were the first who gave an exact description of it. It is the medullary cancer, the fungous inflammation, the fungous hematodes of some English writer.

This tissue exists under the form of denuded or enveloped masses, and also under that of infiltration.

In the state of crudity, it forms masses of various size; each mass is lobed, lobulated, and the lobules are ordinarily turned

like the convolutions of the brain. This tissue is then firm, like the rind of bacon, semi-transparent, without colour, or whitish or grayish; the lobules are united together by an imperfect cellular tissue, of extreme softness; they become confounded in proportion as the mass is developed. Numerous vessels, very fine, and with very weak walls, are ramified in this cellular tissue and in the encephaloid substance itself.

When the development is complete, the encephaloid tumour is of a white colour; violaceous or rose-coloured in different places, either in tints or points. This morbid tissue is then very analogous to the cerebral tissue, but more loose, and less tenacious. It presents otherwise different degrees of consistence in the same mass; degrees comparable to those of different parts of the encephalon.

The encephaloid masses which are not enveloped by a distinct membrane, are so by a layer of soft cellular tissue; others have a demi-cartilaginous envelope, lined, on the interior, with soft and vascular cellular tissue like the first. Sometimes the cyst is incomplete in its development; in all cases it appears to be posterior in its formation to the substance which it contains.

The cerebriform infiltration is very common, especially in the tissue of the neck of the uterus; in this state the period of crudity is very short.

The softening of this tissue gives place to a pultaceous matter of a rose colour. Sometimes then, the vessels giving way, sanguineous infiltration takes place in the cellular tissue, or effusions similar to apoplexy in the softened substance: the blood then concretes, and is in part re-absorbed; sometimes even a membrane like a cyst is formed about the blood; sometimes serous infiltrations take place in the surrounding cellular tissue, or serous effusions in the substance itself, which is then fluid like the white softening of the brain.

Whatever may be the resemblance, in effect very great, between the morbid tissue of which we speak, and the substance of the brain, there is no identity; and we can not admit the opinion of Maunoir, who regards this tissue as the product of an effusion of nervous matter.

When the softening is exterior or in contact with the air, the surface is gray, greenish, fetid, inflamed; sometimes it destroys itself by falling into putrefaction.

This tissue, multiplies itself in the organization, less, however, than the tubercles, especially at the time of the softening. It has a greater tendency than the tubercle to increase or to extend gradually. It does not appear to be susceptible of being eliminated and of curing itself spontaneously.

It may exist in all the organs: it is observed frequently in the mammæ, the testicles, the uterus, the liver, the lungs, the encephalon, the stomach, the periosteum, the dura mater, the bones, their medullary membrane, the serous membranes, the mucous membrane, the muscles, the glands, the lymphatic ganglions, and in the common cellular tissue.

III. OF SCHIRRUS.

§ 839. The schirrous or glue-like tissue is less common than the preceding; it is often confounded with it under the name of cancer.

It exists most commonly under the form of isolated masses.

In the state of crudity, it is difficult to distinguish it from the tuberculous and encephaloid tissues. It is hard; but its consistence varies from that of cartilage, or of the rind of bacon, to that of the intervertebral ligaments. It creaks under the point of the scalpel when scraped; it is white, bluish, gray, little coloured or without colour. It is semi-transparent; it forms masses of irregular figures, rarely lobulated, ordinarily homogeneous; it is sometimes divided in the interior by fibrous or cellular intersections: this interior tissue is sometimes regularly radiated, like that of a turnip, sometimes alveolar, sometimes irregular. Distinct vessels are rarely perceived in it.

Schirrus assumes the consistence of jelly, and sometimes, the appearance of syrup, is sometimes colourless, fulvid, or greenish, sometimes grayish, impure, and stained with blood. Sometimes the softening is gummy, or pultaceous, and at others, like honey.

This morbid tissue presents a considerable diversity of appearance, both in the state of crudity and in that of softening. Bayle enumerates from five to six species of cancers. Several species of the sarcoma of Abernethy belong to this kind of tissue.

Schirrus softens sometimes partially, and then it presents the appearance of cicatrices (Nicod.). In a case of this kind, which I have seen recently, it seemed to me what appeared to be cicatrices was the skin remaining sound in small spots in the midst of a very great number of superficial and irregular ulcerations.

Schirrus has been observed in most parts of the body, in almost all the organs and tissues.

IV. OF MELANOSIS.

§ 840. Melanosis,* *cancer mélané* of Alibert is a morbid tissue characterized by its black colour, which, noticed at first by some observers, both in man and animals, has been specified and named, some years ago by Laennec.

This substance exists under the form of isolated masses, denuded or enveloped, under that of infiltration, and of plates at the surface of membranes.

The masses of melanosis vary, as to size, from the most minute to that of a nut: they exist in a greater or less number in the same individual; they are sometimes tolerably regular, sometimes mamillary, lobulated, sometimes as if formed of laminæ twisted or winding. These parts are united together and the masses surrounded by cellular tissue. The vessels surround this tissue, but do not penetrate into the black substance. This substance is black or brown, opaque, inodorous, tasteless, firm, tenacious, and apparently homogeneous; but if it be broken by percussion, and washed with water, the water becomes coloured with brown or black; the tissue loses its colour and remains grayish.

Melanosis occurs in plates at the surface of the mucous or

* Breschet, *Considérations sur une altération organique appelée dégénérescence noire, etc.* Paris, 1821.

serous membranes; it is found also infiltrated in the substance of the mucous membrane, false membranes, ganglions, &c.

Melanosis, examined chemically, appears composed, 1st, of coloured fibrine; 2d, of a blackish colouring matter, soluble in weak sulphuric acid and in the solution of the subcarbonate of soda, and colouring these fluids red; 3d, of a small quantity of albumen; 4th, of chloruret of sodium, of subcarbonate of soda, of phosphate of lime and oxide of iron.

The composition of melanosis is then very analogous to that of the clot of the blood, that is to say to the colouring matter and fibrine, both in a particular state; three gross substances are also met with in it.

Melanosis softens slowly, under the form of blackish bouillie; and, according to its seat, this substance becomes effused in the cavities, where it infiltrates in such a manner as to colour the humours and tissues. Sometimes, but rarely, subcutaneous melanosis ulcerates; Dr. Ferrus has observed a case of this sort. In the state of softening, even when extreme, this tissue has little tendency to spread or increase; it does not determine in the organization a deleterious action so marked as the preceding. The alterations which have been most often observed are a general decoloration, dropsies, torpor, a debility analogous to what takes place in the scurvy.

Melanosis has been found in many parts, and especially in the common cellular membrane, in the muscles, in the heart, in the lymphatic glands, in the orbit, in the eye, in the lungs, the liver, the kidneys, the pancreas, the spleen, the cellular tissue of the mammæ, the accidental cellular tissue, &c.

Melanosis appears to result from an aberration of some of the materials, and especially of the colouring matter of the blood.

V. OF CIRRHOSIS &c.

§ 841. Cirrhosis, or the fulvid morbid tissue, exists sometimes under the form of masses; it has been seen also under the form of plates and of a cyst.

In masses, this tissue is fulvid, dull, flaccid, humid, compact, analogous to the tissue of the renal capsules: it does not

present distinct fibres. The masses vary from the size of a grain of millet to that of a cherry stone. They exist sometimes in an innumerable quantity. The largest appear squamous.

This tissue softens under the form of greenish brown putrescence; its effects, whether local or general, are slightly marked. It exists frequently and very abundantly in the liver, which is then shrivelled, wrinkled, and rugose. It has been seen also in the kidney, the prostate, the epedidymis, the ovarium, and thyroid.

§ 842. Laennec has designated, under the name of *sclèrose*, a tissue very much resembling or identical with the white compact tissue, and which he found infiltrated in the subperitoneal cellular tissue of the lumbar region in a cancerous individual. It differs from the morbid tissues in that it has not been osberved softened; but it approximates to them by its propensity to spread.

§ 843. The same pathologist has designated, under the name of *squirre squammeux*, a tissue of a semi-transparent, dull, white, foliated like the flesh of a cod, which he once saw enclosed in a pearly cyst, in a cancerous individual.

VI. OF COMPOUND MORBID TISSUES.

§ 844. The morbid tissues are very often associated: their reunion is one of the greatest sources of difficulty in the study of pathological anatomy.

The composition takes place sometimes by simple juxta-position, and sometimes by an intimate and mutual penetration.

The most ordinary combinations are, 1st, those of the fibro-cartilaginous and osseous tissues in the cysts which contain vesicular worms;

2d. The combination of earthy ossification and of the tubercle, especially in the bronchial glands;

3d. That of the tubercle and encephaloid tissue, frequent in the liver and testicles;

4th. That of schirrus and earthy ossification, common also in the liver;

5th. That of all the morbid tissues, with ossifications, with

other analogous productions, inflammation, hypertrophy, serous, sanguineous, and purulent infiltrations, &c.; which constitutes the compound cancers of the stomach, of the mammæ, &c.

SECTION IV.

OF FOREIGN ANIMATED BODIES.

§ 845. The animals* which are met with in the organization, and which live at its expense, are, on the one hand intestinal worms, and on the other animals attached to the surface of the body, penetrating into its substance, introduced into its cavities, &c. The knowledge of these beings is one of the parts of medical natural history the most difficult and most obscure from the want of exact observations.

ARTICLE I.

OF INTESTINAL WORMS.

§ 846. Intestinal worms or entozoary,† *entozoa* (Rudolphi,) are formed, or at least are born and inhabit within the organization; they can not live elsewhere. They are found not only in the alimentary canal and ducts which are inserted in it, but even in the cellular tissue, in the muscles and in the substance of organs which are the most distant from the surfaces of the body, as the brain. Their organization presents many and great varieties (38). Their origin is very obscure. Confining ourselves to the indication of those which inhabit the human body, they may be referred to three orders, viz.: vesicular worms, flat worms and cylindrical worms.

* J. H. Ioerdens, *Entomologie und helminthologie des menschlichen horpers, etc.*, 1801–1802.

† C. A. Rudolphi, *Entozoorum, sive vermium intestinalium Hist. natur.* Parisiis et Argentorati, 1810.—*Idem, Entozoorum synopsis.* Berolini, 1819.

I. OF VESICULAR WORMS.

§ 847. Vesicular worms,* *Entozoa cystica*, (Rud.) consist in great part, of a caudal vesicle more or less voluminous, peculiar to a single or common to several worms: the body is depressed or rounded, always very small; the head (wanting in one genus) is furnished with pits (two or four,) with suckers (four,) with a crown of hooks or of four recurved probosces; there is no visible intestinal canal or genital organs. These worms inhabit always the substance of the organs in a distinct cyst; they have been confounded together for a long time, and with cysts, under the name of hydatids. Even now naturalists reject one or two genera from this order, which consists of the following: *Acephalocystis, Echinococcus, Cysticerus*, and *Diceras*.

§ 848. The acephalocystis,† a genus established by Laennec, but not adopted by Rudolphi, or by Cuvier, consists in a vesicle, without head or body, round or obround, from the size of a little pea to that of a middling apple, with thin and soft, transparent, whitish, homogeneous, fragile walls, filled with a limpid, aqueous, and albuminous fluid. It is doubtful whether spontaneous movements have been observed in it. It appears that these equivocal beings reproduce by interior buds. They have been met with in almost all the organs. Seven or eight species are known. They are always encysted, if we except the clustered mole, which is regarded as the result of the reunion or of the suture of one species of this genus.

§ 849. The echinococcus, a genus of Rudolphi, which comprehends perhaps the acephalocystis, and which Cuvier does not admit, consists in a simple or double external vesicle, to the internal surface of which are attached several worms, fine and granulated like grains of sand, whose body is ovoid, and the head (like that of the armed tænia) furnished with a crown of hooks and suckers.

* Laennec, *Mémoire sur les vers vésiculaires, &c.*, in the *Bulletin de l'Ecole de médicine*. Paris, an. xiii.

† Laennec, *loc. cit.*—Ludersen, *Diss. de hydatidibus;* Gotting., 1808.—H. Cloquet, *Faune de médecins*, tom. i. Paris, 1822.

One species, the echinococcus of man, *E. hominis,* inhabits the viscera of man, and especially the liver.

§ 850. The cysticercus has the body rounded or depressed, rugose, terminating in a caudal vesicle; its head (like that of the armed tænia) is furnished with four suckers and with a recurved proboscis. It inhabits solitarily a very thin cyst.

The cysticercus of the cellular tissue, *C. cellulosæ,* has the head square, the neck very short and inflated before, the body cylindrical elongated, the caudal vesicle elliptical transversely, and is the species so common in the hog; it is met with sometimes in the muscles, the brain, and the heart of man. Some other species are also found in the human body.

§ 851. The rough diceras, *D. rudis,* has the body ovoid and depressed; it has a loose tunic; its head is provided with a bifid, rough, filamentous horn. It is not exactly known whether it inhabits the substance of organs. It was discovered by Sultzer, in the matters discharged by the action of a purgative. Considered doubtful by Rudolphi, it has been found since by Le Sauvage, de Caen, who has sent individuals to the Société de la Faculté de Médecine, where I saw them.

II. OF THE FLAT WORMS.

§ 852. The flat worms are those whose soft and depressed bodies is provided with sucking-pores at its inferior surface or at its extremities, *entozoa trematoda,* (Rud.), and those whose body is elongated, continuous, or articulated, and the head furnished with pits, with suckers, with one or four proboсces, naked or armed, *Ent. cestoidea,* (Rud.) Both are deprived of an intestinal canal, and provided with ramified ovaries. This order comprehends in the human body the genera *Tænia, Distoma,* and *Polystoma.*

§ 853. The tænia have the body very much elongated, flat, and articulated, and the head furnished with two or four little suckers. Two species are found in man.

The broad or unarmed tænia, *T. lata, Bothriocephalus latus,* (Bremser, Rud.), has the head nearly square, two naked pit-suckers, the head and the pits, which are marginal, oblong,

the neck almost wanting, the anterior articulations in the form of wrinkles, those which follow are broad and short, the last elongated; its length is twenty feet or more. This species is common in Switzerland and Russia, very rare in England, Holland, and Germany. It is not found in dead bodies.

The solitary or armed tænia, *T. solium,* called also commonly, and improperly, solitary worm, has the head furnished with four suckers, and an obtuse proboscis, armed with hooks in their centre; the head is hemispherical, and distinct; the neck thickens anteriorly; the anterior articulations are very short, the following elongated, the last longer, all obtuse, provided each with a marginal pore, alternating indefinitely sideways; its length is from five to ten feet and more. This species is common in England, Holland, and Germany. It is sometimes met with in dead bodies.

Both species are found in France, but particularly the second. They both inhabit the intestinal canal, especially the small intestines.

§ 854. The distoma, or the *fasciola*, (Lin.) has the body soft, depressed, and two solitary pores, one anterior and one ventral.

The hepatic distoma, *D. hepaticum*, which has the form of an oval leaf, is met with in the gall bladder of man and of many other animals, particularly of the sheep.

The polystoma, *hexathyridium*, (Treuther,) has the body depressed, six anterior pores, one ventral, and one posterior. The P. of the fat, *P. pinguicola*, which is truncated before, pointed behind, has been met with in a tumour of the human ovary. The polystoma of the veins, *P. venarum*, appears to be an external worm.(457)

III. OF CYLINDRICAL WORMS.

§ 855. The cylindrical worms, *Ent. nematoidea*, (Rud.), have the body elongated, rounded, and elastic; they have an intestinal canal, terminated by a mouth and anus, genital organs, separate on two different individuals. This order com-

prehends, in man, the three following genera: *Filaria*, *Trichocephalus*, and *Ascaris*.

§ 856. The ascaris has the body round, tapering at the two ends, the head furnished with three tubercles; the penis of the male is pointed and bifid. Two species are found in the human body.

The *A. lumbricoides*, the head of which is naked, the body several inches long (3 to 12), marked with two opposite furrows, the tail a little obtuse, inhabits the small intestines. The *A. vermicularis*, *Oxyuris vermicularis*, (Bremser), has the head obtuse, furnished with a vesicular membrane on each side; its body is a little thickened anteriorly; the tail of the male is flexed and obtuse; that of the female is straight and flattened. It inhabits the large intestines, especially the rectum.

§ 857. The trichocephalus has the anterior part of the body capillary, the rest suddenly a little more voluminous; the mouth orbicular; the penis simple, and sheathed.

The *T. dispar* is found in man: it is unarmed; its capillary part is very long, its head pointed; the body of the female is nearly straight; that of the male is spiral; the sheath of the penis is ovoid. This worm, observed by Morgagni, Wrisberg, Rœdorer, and Wagler, is very common. It inhabits the large intestines, and especially the cœcum.

§ 858. The filaria has the body elongated and nearly equal, the mouth orbicular; the penis of the male is pointed and simple.

The *F. medinensis*, which is very long, which has the head slender, the tail flattened and flexed in the male, semi-cylindrical, pointed, and curved in the female, is met with in the human species, but only between the tropics. It inhabits the subcutaneous cellular tissue, especially that of the feet. It was thought formerly to be an exterior penetrating worm; it appears to be really an entozoary one. The F. of the bronchiæ, *F. bronchialis*, is a doubtful species, observed and described by Treutler, under the name of *Hamularia lymphatica*.

§ 859. The *strongylus gigas* has been numbered among the worms which inhabit the human body, because Ruysch says

that he once saw in the kidneys of man, worms similar to those of the kidneys of the dog.

The *spiroptera hominis* is a species yet doubtful, observed by Messrs. Barnett and Lawrence, and discharged from the urinary bladder of a woman.

H. Cloquet has recently described under the name of *Ophiostoma ponterii*, a worm thrown up by a man in vomiting, and observed by Pontier.

Many other worms have been indicated as inhabiting the human body, which are only found in animals; others are only larvæ, or other objects more or less analogous to the worms which are found accidentally in excretions, or which have been placed there by deception.

ARTICLE II.

OF PARASITIC ANIMALS.

§ 860. Parasitic animals are much more foreign to the organization than the entozoaric.

Some of them however are insects born, living, and reproducing themselves on the surface and within the substance of the skin: such are the *Pediculus humanus corporis*, *P. capitis*, *P. pubis*, *Pulex irritans*, *P. penetrans*, and the *Acarus scabiei* or *sarcoptes*.

Other insects are deposited under the skin and in the mucous cavities, in the state of eggs, develope themselves in the state of larvæ, and come out afterwards: such is the *Oestrus*, so common in the horse, the ox, the sheep, and which has been found also under the skin of man and in the sinus of the face. Larvæ of the genus *Musca* and of some others, develope themselves also sometimes in the auricular passage of children which are not kept clean, at the surface of ulcers, &c. We must not forget that many cases of larvæ excreted should be referred to deceptions or fortuitous cases.

§ 861. Certain other animals penetrate, in the adult state, into the mucous cavities of the body, remain there a greater

or less time, and cause different affections: such are, among others, leeches *Hirudo medicinalis*, and *H. alpina;* such is probably also the hair-worm, *Gordius.* It has been thought that the earth-worm could penetrate into the body, it is the effect either of a mistake or of deception. The Furia Infernalis of Linnæus appears to be an imaginary worm.

Some insects, finally, only mechanically wound the exterior surface of the body, or deposit a venom in it; they are otherwise entirely foreign to it.

THE END.